HARIDUS- JA TEADUSMINISTEERIUM
MINISTRY OF EDUCATION AND RESEARCH

TARTU OBSERVATOORIUMI AASTARAAMAT

2011

ANNUAL REPORT TARTU OBSERVATORY

TÕRAVERE 2012

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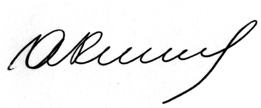
Contents Sisukord

Eessõna

Aastal, kui tähistasime koos Tartu Ülikooliga Eesti astronoomiaajaloo 200-ndat sünnipäeva vana Tartu Tähetorni renoveeritud hoones uue muuseumi avamisega, algas lõpuks ka meie oma peahoone ümberehitus. Kuigi planeerimine ja pakkimine olid kestnud juba üle aasta, tuli suvel suure kuumaga kolimine ikkagi ootamatult ning vaid paari kuuga olid kõigile armsaks saanud tööruumid muutunud varemeteks. Jälgime hoone renoveerimist ärevusega uskudes, lootes ja tegutsedes nii, et lisaks välisele vormile ka siin tehtava teaduse sisu saaks olema jätkuvalt väärikas. Eesti kosmosevaldkonna arengukava alusel vormistasime oma teadustegevuse strateegilised suunad astronoomias, kosmoloogias, kaugseires ja kosmosetehnoloogias koos ekspertidega Eestist ja välismaalt seminaril ”Modern trends in Space research”. Ühiselt järeldasime, et vastavus ühiskonna vajadustele on peamiseks võimaluseks realiseerida oma potentsiaali uue põlvkonna tunnustatud kosmoseteadlaste kasvatamisel ning moodsa tehnoloogia arendamisel. See vajadus võib ilmneda nii nõudena teadusmahuka ettevõtluse toetamiseks ja käivitamiseks, mida me teeme Euroopa Kosmoseagentuuri ja Euroopa Liidu rahastatud projektide kaudu või ka tipptasemel baasuuringute läbiviimiseks. Suure tunnustuse ja ka vastutusena meie kosmoloogidele alustas 2011. a koostöös Keemilise ja Bioloogilise Füüsika Instituudiga tippkeskus ”Dark Matter in (Astro)particle Physics and Cosmology”, mille eesmärgiks on laiendada inimkonna teadmisi tumeaine olemuse kohta. Tihenenud rahvusvahelised suhted inspireerivad nii kogenud kui ka noori teadlasi. Konverents ”Expanding the Universe” tõi Tartusse astronoome 10 riigist arutlema kosmoloogiliste paradigmade muutumise üle läbi aegade ning näitas ka Tartu Observatooriumiga seotud uurijate silmapaistvat rolli selles. Suur rõõm on ka, et kolm meie noort teadlast kaitsesid oma doktoritööd. Nii ongi meil olnud sel aastal palju tegemist ja ajutistes tööruumides ebamugavusi nagu ei märkagi!



Anu Reinart
Direktor

Tõraveres
veebruar 2012

Foreword

Together with University of Tartu we celebrated the 200 years anniversary of astronomical research in Estonia. On the same year, when new museum was opened in Old Observatory in Tartu, Tartu Observatory finally started renovation and modernization of its main building in Tõravere. Even the planning took much longer time than expected, we will have new complex for specific laboratories, visitor centre and scientifically improved working conditions for researchers by the end of year 2012. On the bases of Estonian Space Strategy document we formed also the scientific priorities for Estonian researchers in the field of astronomy, cosmology, Earth observations and space technology. Through discussions with international experts and national authorities it was concluded that there is strong requests from the society for space research. Global challenges like adaptation with the changing environment, the need for effective use of energy and rapid increase of Earth population force countries to look for new and innovative technologies. Space technology has a significant role to play in meeting these challenges. Projects funded by European Space Agency and European Union framework program that are currently carried out in observatory, certainly support these goals. The basic research in department of cosmology was acknowledged by establishing centre of excellence ”Dark Matter in (Astro)particle Physics and Cosmology” under leadership of Institute of Chemical Physics and Biophysics. During next four years studies in astroparticles and dark matter theory in combinations with the results form cosmological observations, simulations, direct and indirect dark matter detection experiments will be done. Close international collaboration inspires both experienced and young researchers and generates new ideas. On the conference ”Expanding the Universe” participated researchers from more than 10 countries and discussed about the role of our astronomers in shifting cosmological paradigms. Positive step towards the rise of new generation is also that three of our colleagues defended their doctoral thesis this year. We have been so busy that uncomfortable working conditions in temporal rooms can not be even noticed!

Anu Reinart
Director

Tõravere
February 2012

1 Ülevaade

1.1 Uurimisteemad ja grandid

1.1.1 Sihtfinantseeritavad teadusteemad

2011. aastal jätkus Tartu Observatooriumis (TO) kolme sihtfinantseeritava teadusteema täitmine.

- Tumeenergia, tumeaine ja struktuuri teke Universumis (teema juht E. Saar) – 223 690 EUR.
- Evolutsiooni hilisfaasis tähtede ja nende ümbriste vaatluslik ja teoreetiline uurimine (teema juht T. Kipper) – 280 520 EUR.
- Taimkatte kvantitatiivne kaugseire (teema juht A. Kuusk) – 80 150 EUR.

1.1.2 Eesti Teadusfondi grandid

Sihtasutus Eesti Teadusfond rahastas 7 granti:

- Grant 7725: A. Kuusk – Metsa peegeldusindikatriss – 18 245 EUR.
- Grant 7765: U. Haud – Nähtav ja varjatud aine galaktikates – 9 816 EUR.
- Grant 8005: E. Saar – Valguskoonused: kosmiliste struktuuride areng – 16 349 EUR.
- Grant 8290: M. Lang – Kaugseire, metsanduslike andmebaaside ning metsakasvu ja -heleduse mudeli lõimimine pideva metsakorralduse süsteemi poolboreaalsete metsade jaoks – 13 771 EUR.
- Grant 8906: L. Leedjärv – Täheassotsiatsioonide heledaimate tähtede muutlikkuse uuring – 9 200 EUR.
- Grant 8970: J. Envall – Optiliste kaugseiremõõtmiste täpsust mõjutavad metroloogilised faktorid – 6 000 EUR.
- V. Russak oli üks põhitäitja TÜ dotsendi H. Ohvrili grandis nr. 7347 ”Atmosfäärisamba veeauru ja aerosooli sisalduse füüsikalise analüüsi meetodite arendamine Läänemere piirkonna keskkonnaseisundi uurimiseks” (3 346 EUR Tartu Observatooriumile).

Need grandisummad ei sisalda asutuse üldkululõivu. Viimane (20% grantide summast) eraldati otse observatooriumi eelarvesse.

Alates 2008. aastast annab Eesti Teadusfond välja ka järeldoktorite grante ja nn mobiilsusgrante. Kolm taotlejat töötasid 2011. aastal Tartu Observatooriumis:

- ETF järeldoktori grant JD 189: E. Jakobson – Atmosfääri optiliste omaduste muutlikkus Läänemere regioonis kaugseire rakenduste seisukohalt – 26 270 EUR.
- Mobiilsusgrant ERMOS-32: J. Pisek – Taimkatte grupeerumisindeksi määramine satelliidisensori MERIS mitme vaatesuuna mõõtmisandmetest – 23 630 EUR.

- Mobiilsusgrant ERMOS-35: G. Hütsi – Kosmiline suuremastaabiline struktuur: efektiivne vahend fundamentaalfüüsika kontrolliks – 22 900 EUR.

1.1.3 Euroopa Liidu 7 raamprogrammi projektid

- Lõppes EL 7. raamprogrammi projekt (EstSpacE) "Eesti kosmoseuuringute ja -tehnoloogia võimekuse avamine partnerluse kaudu tipptasemel Euroopa teadusasutustega" (01.03.2008–28.02.2011): A. Reinart – 131 456 EUR.
- Jätkus EL 7. raamprogrammi projekt (WaterS) "Täiustatud vee kvaliteedi parameetrite määramine optilisest signatuurist strateegilise partnerluse abil" (01.06.2010–31.05.2014): Konsortsiumi koordinaator A. Reinart – 112 151 EUR.
- Jätkus EL 7. raamprogrammi projekt (ESAIL) "Elektrilise päikesepurje tehnoloogia" (01.12.2010–30.11.2013): TO koordinaator M. Noorma – 55 799 EUR.

1.1.4 Euroopa komoseagentuuri Euroopa koostööriikide programmi projektid

- Projekt (ORAQUA) "Teenusepõhised optilise radiomeetria rakendused veekeskkonna jaoks" (01.12.2011–31.12.2013): A. Reinart – 90 171 EUR.
- Projekt (GAIA) "Emissioonijoontega tähtede klassifitseerimine Gaia kataloogis" (01.01.2011–31.12.2013): L. Leedjärv – 34 791 EUR aastas.

1.1.5 Euroopa Liidu struktuuritoetused

- Projekt (3.2.0201.10–0013) "Tartu Observatooriumi infrastruktuuri arendusprojekt" (01.06.2008–31.12.2014): A. Reinart – 515 674 EUR.
- Eesti teaduse infrastruktuuri teekaardi objekti – *Eesti osalus Euroopa Kosmoseagentuuris*, ettevalmistustööd (15.05.2011–31.10.2011): A. Reinart, S. Lätt – 6 391 EUR.
- Eesti teaduse infrastruktuuri teekaardi objekti – *Eesti osalus Euroopa Lõunaobservatooriumis*, ettevalmistustööd (12.05.2011–30.10.2011): L. Leedjärv, A. Reinart, A. Tamm – 6 391 EUR.
- Projekt (3.2.0302.10–0144) "Kaugseire etalonide komplekslabor" (01.01.2010–30.04.2012): A. Reinart, A. Kuusk – 83 213 EUR.
- Projekt (3.2.0302.10–0143) "1,5 meetrise teleskoobi juhtimissüsteemi moderniseerimine" (01.01.2009–31.03.2012): K. Annuk – 173 546 EUR.
- Teaduse tippkeskuste arendamise projekt (3.2.0101.11–0031) "Dark matter in (Astro)particle Physics and Cosmology" (2011–2015): E. Saar – 37 336 EUR.

- Projekt (3.2.0301.09–0009) ”Optiliselt keerukate looduskeskkondade kaugseire” (01.01.2010–31.12.2011): I. Ansko – 17 616 EUR.
- Projekt (3.2.0301.10–0236) ”Evolutsiooni hilisfaasides tähtede ja nende ümbriste vaatluslik ja teoreetiline uurimine” (Robotteleskoop) (01.01.2011–31.12.2012): L. Leedjärv – 55 131 EUR.

Lepingud on sõlmitud ka järgmistele projektidele:

- Projekt (3.2.0302.11–0290) ”Kosmosetehnoloogia laboratoorium” (01.01.2010–31.12.2013): M. Noorma.
- Projekt (3.2.0302.11–0272) ”Satelliidimaajaam” (01.01.2010–06.06.2013): S. Lätt.
- Projekt (3.2.0902.11–0003) ”Tartu Observatooriumi teleskoobi tornide tuleohutusnõuetega kooskõlla viimine ja juurdepääsetavuse suurendamine” (01.10.2011–31.12.2012): E. Ruusalepp, D. Toots – 1 920 EUR.

1.1.6 COST projektid

- Prognoositav kliimamuutus ja selle mõju Euroopa metsandusele, COST projekt FP0703, 2009–2012: TO koordinaator – M. Lang.
- Spektrimõõtmiste vahendid taimkatte biofüüsikaliste parameetrite ning voomõõtmistornide andmete jaoks Euroopas. COST projekt ES0903 (2009–2013): TO koordinaator – M. Lang.

1.1.7 Muud projektid ja lepingud

- Eesti Terminoloogiaühingu (ETER) toetus kosmoseterminoloogia korrastamiseks: U. Veismann – 800 EUR.
- Loodusdirektiivi elupaikade kogupindalade leidmine ja pindala muutuste hindamine kaugseire meetoditega, Keskkonnaministeerium: U. Peterson – 3 070 EUR.
- Riikliku keskkonnaseire programmi allprogramm ”Eesti maastike muutuste uuringud ja kaugseire”. Keskkonnaministeerium: U. Peterson – 9 587 EUR.
- Kaugseirealased konsultatsioonid AS Regio projektile ”Elektriliinide koridoride seire kõrglahutusega multispektraalsete satelliidipiltide põhjal ohtlike puude tuvastamiseks” 02.05.2011–30.09.2011): T. Nilson – 4 800 EUR.
- Metoodikate väljatöötamine AS Regio ESA PECS projektile ”Improving the Quality of Greenhouse Gas Inventory in Estonia – Estimating Forest and Wetland Emissions, Removals and Carbon Stocs” (01.05.2011–31.11.2012): T. Nilson – 6 000 EUR.

Nende teemade ja projektide raames tehtust leidub põhjalikum ülevaade peatükkides 3–5.

1.2 Töötajad

Observatooriumi töötajaskonnas toimusid mitmed muutused:

- 1. märtsist alustas tööd info töörühma asjaajaja Ulvi Nigol.
- 30. aprillil lõppes järeldoktor Margus Saali tööleping ning ta lahkus observatooriumist.
- 22. juunil siirdus pensionile kauaaegne raamatupidaja Helju Eller.
- 16. augustist töötab atmosfäärifüüsika osakonna atmosfääri seire töörühmas insenerina 0.25 koormusega Hannes Keernik.
- 31. augustil lõppes tööleping atmosfäärifüüsika osakonna atmosfääri seire töörühma inseneri Johann Kütt'iga.
- 5. oktoobril lahkus töölt projektijuht Ain Jõesalu.
- 1. detsembrist töötab atmosfäärifüüsika osakonna atmosfääri seire töörühmas tarkvara insenerina Henri Kuuste ja info töörühmas projektijuhi abina Diana Toots.
- 31. detsembril lõppes tööleping erakorralise vanemteaduri Jouni Envalliga.

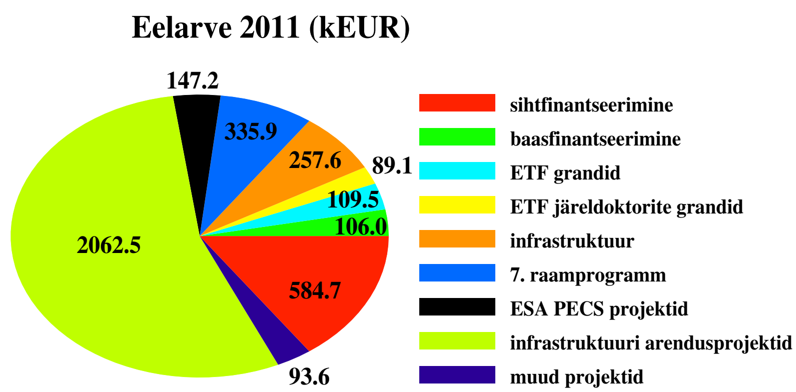
2011. aasta oli edukas meie noortele teadlastele: Tartu Ülikoolis kaitsesid oma doktoriväitekirju kosmoloogia töörühma teadur Elmo Tempel (03.06.2011), taimkatte seire töörühma teadur Joel Kuusk (24.08.2011) ja tähefüüsika töörühma teadur Anti Hirv (26.08.2011).

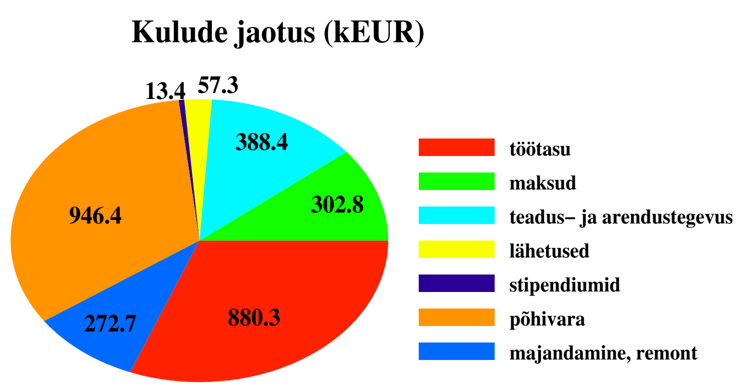
Kõigi muutuste tulemusena oli 31. detsembril 2011 Tartu Observatooriumis tööl 83 inimest, neist 50 teadustöötajat ja 12 teadustööd tegevat inseneri.

1.3 Eelarve

Riigieelarvest eraldati Tartu Observatooriumile 2011. aastal 1 149,285 kEUR. Lisaks laekus *ca* 2 639,245 kEUR mitmesugustest koostööprojektidest ja lepingutest, mida on nimetatud osades 1.1.3–1.1.7, ning observatooriumi infrastruktuuri renoveerimise projekti arvelt.

Tulud ja kulud jagunesid järgnevalt:





Observatooriumi teadlaste keskmine töötasu 2011. a lõpul oli 1227 EUR kuus.

1.4 Aparatuur ja seadmed

Euroopa Liidu struktuuritoetuste "Majanduskeskkonna arendamise rakenduskava" alameetmest "Teadus- ja arendusasutuste teadusaparatuuri ja seadmete kaasajastamine" rahastati Tartu Observatooriumi nelja projekti:

- TAP13-1 – 2011. aasta jooksul toimus 1,5-meetrise teleskoobi juhtimissüsteemi moderniseerimine. Tööd teostas ABB AS, kes vahetas välja kogu teleskoobi elektrijuhtmestiku, mootorid teleskoobi ja kupli liigutamiseks, kõik elektrikilbid, juhtpuldid, andurid jne. Teleskoop on nüüd täielikult arvuti abil juhitav. Tarkvara võimaldab suunata teleskoopi kiiresti ja sujuvalt etteantud koordinaatidega objektile.
- TAP13-2 – 2011. aasta jooksul hangiti veekogude kaugseireks täiendav spektroradiomeeter TriOS RAMSES ACC-VIS ja lisaseade välikalibreerimisteks. Nüüd on töörühmal olemas täielik seadmekomplekt veekogude spektraalse peegeldusteguri mõõtmiseks.
- TAP21-1 – 2011. aastal alustati ettevalmistustöid kosmosetehnoloogia labori sisustamiseks, selleks saadi toetust 105 544 EUR.
- TAP21-2 – 2011. aastal alustati ettevalmistusi satelliidimaajama seadmete soetamiseks, selleks saadi toetust 104 500 EUR.

Teaduse väikemahulise infrastruktuuri kaasajastamiseks:

- osteti kaugseire sihtfinantseeritava teema raames arvutijuhitav pöördlaud spektromeetrite nurkkarakteristikute uurimiseks ning hangiti tsentraliseeritud kaugseire andmebaasi ja analüüsi süsteem, mis võimaldab koguda, hoida ning kiiresti töödelda kaugseires kasutatavaid satelliidipilte regioonide pikaajaliste keskkonnamuutuste, vee seisukorra, metsade tootlikkuse, CO_2 bilansi ja muude karakteristikute hindamiseks.
- osteti tähefüüsika sihtfinantseeritava teema raames Raivo Heina kingitud teleskoobikomplekti tarbeks olemasolevale teleskoobipaviljonile automatiseeritav kuppel, suureformaadiline CCD-kaamera, fotomeetriliste filtrite komplekt koos filtriturelliga ilmajaam ning pilvisuse sensorid. Sellise seadmekomplekti abil on võimalik käivitada etteantud uurimisobjektide loetelu põhjal autonoomselt vaatlusi teostav kaugjuhitav robotteleskoop, mis võimaldab ära kasutada ka osaliselt selgeid öid.

Lisaks:

- Tartu Observatooriumi ja Tartu Ülikooli Eesti Mereinstituudi kaugseire-alase ühisteema infrastruktuuri arendamise meetme toel osteti taimkatte kaugseire töörühmale uus suurema kandejõuga raadio teel juhitav väikekopter ning sellele autopiloot, mis suudab kopterit juhtida lendama mööda etteantud GPS-punktidega trassi.

- Koostöös firmaga Hohenheide OY (Toomas Kübarsepp, Madis Lepist) valmis lõksdetektor kiirgusallikate absoluutseks radiomeetriliseks kalibreerimiseks, mis võimaldab luua detektoripõhise radiomeetriaskaala.
- Teleskoop Zeiss 600 on nüüd varustatud EstSpacE projekti raames ostetud suureformaadilise CCD-kaameraga Ikon-L. Saadav praktiliselt vinjeteerimata vaateväli on 13x13 kaareminutit, võrdluses eelmise kaamera ca 4x4 kaareminutilise vinjeteerimata väljaga on edasiminek väga suur. Vaatlusi on võimalik teha Johnson-Cousins fotomeetrilistes filtrites. Uue väga väikese omamüraga kaameraga on teleskoobi küündivus kasvanud ligikaudu ühe tähesuuruse võrra.
- Ultraviolettkiirguse spektromeetri Benthami juurde kuuluvaid etalonkiirgureid kasutades kalibreeriti Terviseameti ja Eesti Rahva Muuseumi ultraviolettkiirguse mõõtevahendeid (U. Veismann).

1.5 Teadusnõukogu töö

Tartu Observatooriumi teadusnõukogu töötas järgmises koosseis:

Anu Reinart – Tartu Observatooriumi direktor, teadusnõukogu esimees,
Gert Hütsi – järeldoktor, teadustöötajate valitud liige,
Ene Kadastik – Haridus- ja Teadusministeeriumi teadusosakonna peaekspert,
Marco Kirm – Tartu Ülikooli Füüsika Instituudi direktor,
Andres Kuusk – vanemteadur, teadustöötajate valitud liige,
Laurits Leedjärv – vanemteadur, teadustöötajate valitud liige,
Mart Noorma – erakorraline vanemteadur, teadustöötajate valitud liige,
Martti Raidal – Keemilise ja Bioloogilise Füüsika Instituudi vanemteadur,
Enn Saar – vanemteadur, teadustöötajate valitud liige,
Antti Tamm – teadur, teadustöötajate valitud liige,
Elmo Tempel – teadur, teadustöötajate valitud liige,
Peeter Tenjes – vanemteadur, teadustöötajate valitud liige.

Teadusnõukogu pidas kolm koosolekut. Kuna teadusnõukogus enam ei kuulata teaduslikke ettekandeid, siis uueks teadlaskonna kokkusaamise viisiks on nüüd observatooriumi ühisseminar. Nimetatud seminaris esinejad ja nende ettekannete pealkirjad on toodud leheküljel 104.

28. märtsi koosolekul kinnitati lõppenud ETF grantide lõpparuanded. Aruanded esitasid A. Tamm (grant 7115), K. Eerme (grant 7137), M. Gramann (grant 7146) ja V.-V. Pustynski (grant 7691). Teadusnõukogu kinnitas ka U. Petersoni poolt Keskkonnaministeeriumiga sõlmitud riikliku keskkonnaseire allprogrammi "Eesti maastike muutuste uuringud ja kaugseire" raames tehtud tööde aruande.

19. septembri koosolekul määrati juba traditsioonilised E.J. Öpiku ja J. Rossi nimelised stipendiumid Tartu Ülikooli doktorantidele. Ettekannetega esinesid:

Jaan Laur: Katikupõhine mõõteskeem ülikiires fotomeetrias (E.J. Öpiku nimelise stipendiumi taotleja) ja

Martin Ligi: Naabrusefekti mõju satelliitsensori MERIS tulemitele (J. Rossi nimelise stipendiumi taotleja).

Toimus ka sihtfinantseeritavate teadusteemade jätkutaotluste arutelu ja kinnitamine.

14. novembril arutati Eesti teadusagentuuri loomisega seotud protsesse ja nende võimalikku mõju observatooriumi tegevusele. Kandidaatideks ETA hindamiskomisjoni esitame Tartu Observatooriumi vanemteadur Tõnu Viik'i, ja Tiit Kutseri TÜ Eesti Mereinstituudist. Toetame ka Ergo Nõmmiste esitamist TÜ Füüsika instituudi poolt.

Samal koosolekul kinnitati ka sihtfinantseeritava teadusteema "Tumeenergia, tumeaine ja struktuuri teke Universumis" juurde kuuluv teadusaparatuuri kaasajastamise taotlus.

1.6 Suhted avalikkusega

Tartu Observatoorium on olnud populaarne külastuskeskus, eriti koolilaste seas. Aastane külastatavus on kõikunud 5500–6000 huvilise vahel. Seoses Tartu Observatooriumi kapitaalse renoveerimisega võeti tööruumidena kasutusele ka 1,5m teleskoobi tornis asuvad Stellaariumi ruumid ja huviliste suureks kurvastuseks lõpetasime 1. juulist ekskursioonide vastuvõtmise. Kuni selle ajani jõudsime vastu võtta 99 gruppi 2500 huvilisega. Kui 2012. aasta augustis valmib renoveeritud peahoone, siis avame ka Stellaariumi. Selleks ajaks loodame ka ekspositsiooni uuendada.

Vaatamata sellele, et renoveerimistööde tõttu ei saadud Tõraveres huviliste gruppe vastu võtta, jätkus astronoomia populariseerimine, nüüd juba veebipõhiselt saidi *www.astronoomia.ee* kaudu. Pidevalt ilmub sinna uusi artikleid, uudiseid, juhtnööre, mida vaadelda jne. Autorid on observatooriumi noored teadlased ja kogu lehekülge haldab/hooldab Taavi Tuvikene.

Eesti Astronoomia Seltsi egiidi alla korraldasid Tartu Observatooriumi noored astronoomid (T. Liimets, T. Tuvikene ja T. Eenmäe) 10.–14. augustini traditsioonilise astronoomiahuviliste XVI üle-Eestilise kokkutuleku Jõgevamaal, Pala koolis ja kultuurimajas. Astronoomiahuvilised – kelle hulgas on nii kooliõpilasi, üliõpilasi, töötajaid kui ka pensionäre – kogunevad traditsiooniliselt augustikuus perseiidide meteoorivoolu ajal. Kuulatakse professionaalsete astronoomide loenguid, selgetel öödel loendatakse perseiide, käiakse eksursioonil, kuulatakse muusikat jne. Pikema loo nimetatud kokkutulekust kirjutas kokkutuleku üks organiseerija Taavi Tuvikene ja see on avaldatud *Tähetorni Kalenderis 2012*.

Eesti Astronoomia Selts ja AS Fotoluks korraldasid fotokonkursi "Kuu lähivaates ja maastikul", kuhu laekus 164 tööd, neist 115 maastikufoto ja 49 lähivaate kategoorias. Astronoomiahuviliste kokkutulekul autasustati võitjaid. Nimetatud fotodest moodustati näitus, mida eksponeeriti:

- Tartu Ülikooli Ajaloo Muuseumi valge saal, Tartu: 25.08.–11.09.2011.
- Cafe Frens, Pühavaimu 15, Pärnu: 03.10.–30.11.2011.

Rahvusvahelisel Astronoomia Aastal, 2009, Kalju Annuki poolt komplekteeritud astronoomiaalaste piltide näitus oli populaarne ning seda eksponeeriti ka 2011. aastal:

- Waide motell: 05.04.–09.05.2011.
- Türi kultuurimaja: 12.05.–17.06.2011.
- Sänna Kultuurimõis: 01.12.2011.–31.01.2012.

Kooliõpilaste poolt tehtud arvutijoonistuste pildid olid kahes kohas:

- Nõo raamatukogu: 21.02.–22.03.2011.
- Waide motell: 09.05.–31.12.2011.

U. Veismann jätkas kosmoseteemalise terminoloogia korrastamist, inglise-eesti sõnastik on üldkättesaadav aadressil *www.aai.ee/eterkosm/*.

Observatooriumi teadlaste arvukad populaarteaduslikud kirjutised on üksikasjaliselt ära toodud lk. 81 avalikud loengud ja intervjuud lk. 109.

Ilmus Tähetorni Kalender 2012 (88. aastakäik) ja juba traditsiooniline Tähistaeva Kalender 2012. Kalendrite kalendaariumi osa arvutused tegi Alar Puss.

1.7 Tänuavaldused

Meie teadlased on saanud rahalist või muud toetust paljudelt asutustelt üle maailma. Oleme tänulikud kõigile toetajatele, nende nimed leiate ingliskeelsest osast leheküljel 26.

2 Summary

2.1 Research projects and grants

2.1.1 Target financed projects

In 2011, research in the framework of three target financed projects was continued:

- Dark Energy, Dark Matter, and the formation of structure in the Universe (principal investigator E. Saar) – 223 690 EUR.
- Observational and theoretical investigation of stars and their envelopes during advanced evolutionary phases (principal investigator T. Kipper) – 280 520 EUR.
- Quantitative remote sensing of vegetation covers (principal investigator A. Kuusk) – 80 150 EUR.

2.1.2 Estonian Science Foundation grants

The Estonian Science Foundation financed 7 grant projects from our Observatory:

- Grant 7725: A. Kuusk – Angular distribution of forest reflectance – 18 245 EUR.
- Grant 7765: U. Haud – Visible and dark matter in galaxies – 9 816 EUR.
- Grant 8005: E. Saar – Light cones: evolution of cosmic structures – 16 349 EUR.
- Grant 8290: M. Lang – Integration of remote sensing, forest growth and reflectance models with existing databases into continuous inventory systems of hemi-boreal forests – 13 771 EUR.
- Grant 8906: L. Leedjärv – Time-resolved survey of the most luminous stars in stellar associations – 9 200 EUR.
- Grant 8970: J. Envall – Study of metrological factors limiting complex optical measurements in remote sensing and atmospheric research – 6 000 EUR.
- V. Russak participated in the grant 7347 led by H. Ohvril from University of Tartu (3 346 EUR to Tartu Observatory).

Those amounts do not contain institutional overheads. The latter (20% of each grant) was transferred separately to the budget of the Observatory.

The Estonian Science Foundation also financed one post-doc grant and two mobility grants:

- Post-doc grant JD 189: E. Jakobson – Variability of optical properties of the atmosphere in the Baltic Sea region for remote sensing purpose – 26 270 EUR.

- Mobility grant ERMOS-35: G. Hütsi – Large-scale structure of the Universe – a powerful probe of fundamental physics – 22 900 EUR.
- Mobility grant ERMOS-32: J. Pisek – Retrieving foliage clumping index from multi-angle MISR measurements – 23 630 EUR.

2.1.3 The European Commission 7th Framework Programme projects

- FP7 project ”Expose the Capacity of Estonian Space Research and Technology through High Quality Partnership in Europe, EstSpacE” (01.03.2008–28.02.2011) ended: A. Reinart – 131 456 EUR.
- FP7 project ”Strategic partnership for improved basin-scale Water quality parameter retrieval from optical Signatures (WaterS)” (01.06.2010–31.05.2014) continued: Consortium coordinator A. Reinart – 112 151 EUR to TO.
- FP7 project ”Electric sail propulsion technology” (01.12.2010–30.11.2013) continued: M. Noorma – 55 799 EUR.

2.1.4 European Space Agency Programme for European Cooperating States

- Project ORAQUA ”Serviced based on optical radiometry applications for aquatic environment” (01.12.2011–31.12.2013): A. Reinart – 90 171 EUR.
- Project GAIA ”Emission Line Star Classification in the Gaia Catalogue” (01.01.2011–31.12.2013): L. Leedjärv – 34 791 EUR.

2.1.5 Financing from the EU Structural Funds

- Project (3.2.0210.10–0013) ”Renovation and development of Tartu Observatory infrastructure” (01.06.2008–31.12.2014): A. Reinart – 515 674 EUR.
- ”Preparatory work for the Estonian Research Infrastructures Roadmap object – Membership in the European Space Agency (ESA)” (15.05.2011–30.10.2011): A. Reinart, S. Lätt – 6 391 EUR.
- ”Preparatory work for the Estonian Research Infrastructures Roadmap object – Membership in the European Southern Observatory (ESO)” (12.05.2011-30.10.2011): L. Leedjärv, A. Reinart, A. Tamm – 6 391 EUR.
- Project (3.2.0302.10–0144) ”Multipurpose laboratory of remote sensing etalons” (01.01.1010–30.04.2012): A. Reinart, A. Kuusk – 83 213 EUR.
- Project (3.2.0302.10–0143) ”Modernisation of automatic control system of 1.5m telescope” (01.01.2009–31.03.2012) – K. Annuk – 173 546 EUR.
- Project (3.2.0101.11–0031) ”Dark energy, dark matter and formation of structure in the Universe” (2011-2015): E. Saar – 37 336 EUR.

- Project (3.2.0301.09–0009) ”Remote sensing of optically complex natural environments” (01.01.2010–31.12.2011): I. Ansko – 17 616 EUR.
- Project (3.2.0301.10–0236) ”Observational and theoretical investigation of stars and their envelopes during advanced evolutionary phases” (01.01.2011–31.12.2012): L. Leedjärv – 55 131 EUR.

Contracts of the following projects have also been signed:

- Project (3.2.0302.11–0290) ”Space Technology Laboratory” (01.01.2010–06.06.2013: M. Noorma.
- Project (3.2.0302.11–0272) ”Satellite Ground Station” (01.01.2010–06.06.2013: S. Lätt.
- Project (3.2.0902.11–0003) ”Improvement of accessibility to telescope buildings and pavilions of Tartu Observatory” (01.10.2011–31.12.2012): E. Ruusalepp, D. Toots – 1 920 EUR.

2.1.6 COST projects

- COST project FP0703 ”Expected Climate Change and Options for European Silviculture (ECHOES) COST Action 2009–2012”: TO coordinator M. Lang.
- COST project ES0903 ”Spectral Sampling Tools for Vegetation Biophysical Parameters and Flux Measurements in Europe”. COST action, 2009–2013: TO coordinator M. Lang.

2.1.7 Some other projects and contracts

- Regio Ltd. ESA PECS project ”Improving the Quality of Greenhouse Gas Inventory in Estonia – Estimating Forest and Wetland Emissions, Removals and Carbon Stocks”: T. Nilson – 6 000 EUR.
- Consultations to the Regio Ltd. project ”Detecting dangerous trees in the corridors of electric lines using high resolution multispectral satellite images” (02.05.2011–30.09.2011): T. Nilson – 4 800 EUR.
- National programme of environmental monitoring, subprogramme studies on change of Estonian landscapes and remote sensing: U. Peterson – 3 070 EUR.
- Review of declared agricultural parcels with remote sensing methods: U. Peterson – 9 587 EUR.
- Development of (Estonian) space terminology: U. Veismann – 800 EUR.

In addition, our researchers participated in several international projects which did not incur direct income to the Observatory.

A scientific report about the activities within these projects and topics will be given in Chapters 3–5.

2.2 Staff

Some changes in the staff of the Observatory took place:

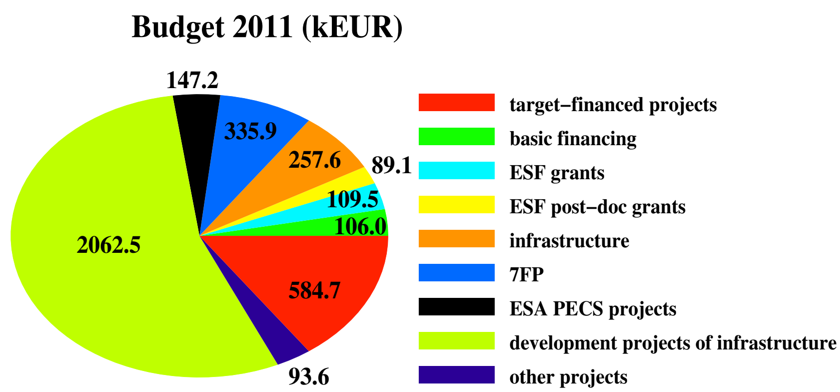
- From March 1, Ulvi Nigol is working as secretary in the group of information.
- On April 30, the contract of post-doc Margus Saal ended and he left the Observatory.
- On June 22, the long-time accountant Helju Eller retired.
- From August 16, Hannes Keernik is working as part-time (0.25) engineer in the group of remote sensing of atmosphere.
- On August 31, the contract of Johan Kütt (engineer in the group of remote sensing of atmosphere) ended.
- On October 5, project manager Ain Jõesalu left the Observatory.
- From December 1, Henri Kuuste is working as software engineer in the group of remote sensing of atmosphere, and Diana Toots as assistant project manager in the group of information.
- On December 31, the contract of senior research associate Jouni Envall ended.

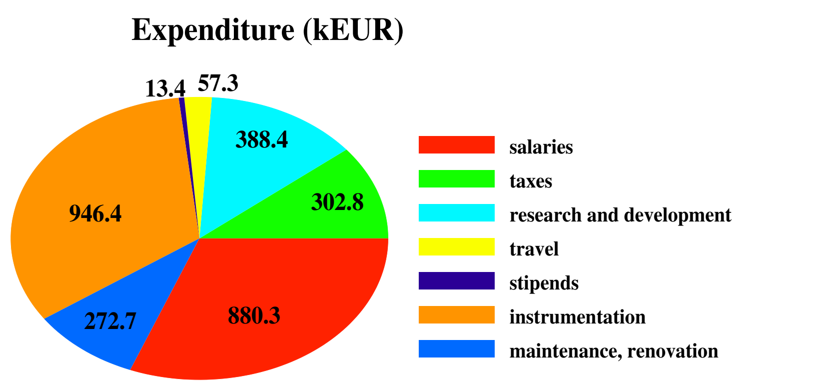
The year 2011 was successful for our young scientists - three Ph.D. theses were defended in the University of Tartu: Elmo Tempel from the group of cosmology (03.06.2011), Joel Kuusk from the group of remote sensing of vegetation (24.08.2011), and Anti Hirv from the group of stellar physics (26.08.2011).

As a result of all the changes, the number of people employed by the Tartu Observatory was 83 on December 31, 2011. Of them, 50 are on the position of researchers and 12 on that of research engineers.

2.3 Budget

The total amount allocated from the state budget directly to the Observatory was 1 149.285 kEUR. In addition, about 2 639.245 kEUR from contracts with several organizations, for renovation of the infrastructure etc. were allocated to the Observatory.





The mean monthly salary of researchers was approximately 1227 EUR by the end of 2011.

2.4 Instruments and facilities

Tartu Observatory was successful to obtain financing for several of its projects from the subprogramme "Modernization of the research apparatus and equipment" of the implementation plan of the European Union structural funds "Development of the economic environment":

- TAP13-1 – During 2011 the control system of the 1.5m telescope AZT-12 was fully modernized. The Estonian branch of the international ABB company performed the work, replacing all the electric motors, electric and signal cables etc. The telescope can now be fully controlled bu the computer. The software enables fast and smooth pointing of the telescope to the object.
- TAP13-2 – A TriOS RAMSES ACC-VIS spectroradiometer and a field calibrator were obtained by the group of vegetation remote sensing. Now the research group has the complete set of instruments for the measurements of spectral reflectance of water bodies.
- TAP21-1 – Laboratory of Space Technology received funding 105 544 EUR and the preparations for equipping the laboratory began on 2011.
- TAP21-2 – Satellite Ground Station received funding 104 500 EUR and preparations for purchase of equipment began on 2011.

For modernisation of small calibre science infrastructure:

- the group of vegetation remote sensing obtained a computer-controlled motorized rotation stage for the study of angular characteristics of radiometers and spectrometers. A centralised remote sensing database and analyse system, which allow collecting, preserving and quickly processing the data from satellite images used in remote sensing for evaluation of longterm environmental changes, condition of water, forest productivity, CO_2 balance and other characteristics;
- Amateur astronomer Mr. Raivo Hein donated to Tartu Observatory a modern 31 cm astrograph PlaneWave CDK 12.5 and a very high quality telescope mount Paramount ME. Given telescope kit will be main instruments of new robotic telescope of Tartu Observatory. Under the theme of stellar-physics targeted financing was bought additional equipment – automatic telescope dome, weather station, cloud and rain detector, large-format CCD-camera, high precision filter wheel with filters and automation software – were ordered and will be installed into existing telescope shelter. Such robotic telescope allows to carry out autonomous observations of listed research targets or control the telescope remotely. Most importantly, very frequent partly clear observing nights can be used for photometric observations.

In addition:

- A radio-controlled helicopter was obtained for spectral measurements of forests using spectrometers developed at Tartu Observatory. The helicopter is equipped with an autopilot which allows flying using GPS-waypoints.
- An optical trap detector was built in collaboration with Hohenheide OY (Toomas Kübarsepp, Madis Lepist) which allows developing a radiometric scale based on radiation detector.
- The telescope Zeiss 600 is now equipped with large-format CCD-camera Ikon-L, acquired during the EstSpacE project. With new camera, unvignetted field of view is approximately 13x13 arc minutes, a big improvement compared to old camera which gave unvignetted field of view about 4x4 arc minutes. Camera is equipped with Johnson-Cousins photometric filter set. Thanks to very low intrinsic noise of the Ikon-L, high-quality photometry of at least one magnitude dimmer stars – compared to old photometer – can be achieved.
- Using the radiation etalons accompanying the Bentham ultraviolet (UV) spectrometer, the UV measurement devices of the national Helth Board and of the Estonian National Museum were calibrated (U. Veismann).

2.5 Scientific Council

Membership of the Scientific Council of Tartu Observatory was appointed in 2010 as follows:

Anu Reinart – director, Chair of the Council,
Gert Hütsi – postdoc, elected by researchers,
Ene Kadastik – chief expert of the department of research policy, Ministry of Education and Research,
Marco Kirm – director of the Institute of Physics, University of Tartu,
Andres Kuusk – senior research associate, elected by researchers,
Laurits Leedjärv – senior research associate, elected by researchers,
Mart Noorma – senior research associate, elected by researchers,
Martti Raidal – senior research associate of the National Institute of Chemical Physics and Biophysics,
Enn Saar – senior research associate, elected by researchers,
Antti Tamm – research associate, elected by researchers,
Elmo Tempel – research associate, elected by researchers,
Peeter Tenjes – senior research associate, elected by researchers.

The Scientific Council does not listen to scientific review talks any more. Such talks are now given on joint seminars of Observatory, and are listed on page 104. The Scientific Council held three meetings in 2011.

On March 28, final reports of the Estonian Science Foundation grants were approved. Grantholders were A. Tamm (grant 7115), K. Eerme (grant 7137), M. Gramann (grant 7146) and V.-V. Pustynski (grant 7691).
The report by U. Peterson on the subprogramme "Studies on change of Estonian landscapes and remote sensing" (Ministry of Environment) was also approved.

On September 19, the Ernst Julius Öpik fellowship was awarded to Ph.D. student Jaan Laur and Juhan Ross fellowship to Ph.D. student Martin Ligi (both from the University of Tartu). Both presented a short reports:
Jaan Laur: Shutter Based Fast Photometry for Faint Objects.
Martin Ligi: Impact of Adjacency Effect to Satellite Sensor MERIS Products.
Applications for continuation of target financed projects were also approved.

On November 14 was the discussions about the formation of Estonian Research Agency. Our nomitation of candidates for the evaluation committe: Tõnu Viik, Tiit Kutser (University of Tartu) and also we support Ergo Nõmmiste from the University of Tartu.

2.6 Public relations

Over the years, Tartu Observatory has been a popular scientific centre to visit, in particular among schoolchildren. However, in 2011 a major renovation of the main building of the Observatory started and the rooms in the Stellaarium were transformed to working offices and meeting rooms for the staff of the Observatory. As the 1.5m telescope was also undergoing renovation at the same time, we could not accept any visitors after July 1, 2011. During the first half of the year, about 2500 visitors in 99 groups were received. We expect to be in full capacity for accepting excursions after August 2012, and hope to upgrade our expositions by this time.

Popularization of astronomy, however, continued, to large extent at the Internet site *www.astronoomia.ee*. The flow of news, press releases, observing instructions etc. is managed by Taavi Tuvikene.

Young astronomers of the Observatory (T. Liimets, T. Tuvikene, T. Eenmäe), under the Estonian Astronomical Society, organized traditional all-Estonian annual meeting of amateur astronomers at Pala, Jõgeva County, from August 10 to 14. It was the 16th time when interested pupils, students, working people, pensioners etc. are gathering at the time of Perseid meteor shower, in order to listen to the lectures, count meteors, listen to music, visit interesting nature sites etc.

The Estonian Astronomical Society and the company Fotoluks organized a competition of (digital) photos "The Moon in big plan and in the landscape”. Altogether 164 photos were submitted of which the jury selected the best ones. Their authors were honoured during the all-Estonian meeting of amateur astronomers in August. The exhibition of the best photos was exposed:

- The white Hall of the University of Tartu History Museum, Tartu: 25.08.–11.09.2011.
- Cafe Frens, Pärnu: 03.10.–30.11.2011.

On the occasion of the International Year of Astronomy 2009, an exhibition of large astronomical photos was compiled by Kalju Annuk. It continued to be popular in 2011 and was exposed as follows:

- Waide motel, Tartu County: 05.04.–09.05.2011.
- Türi kultuurimaja: 12.05.–17.06.2011.
- Sänna Kultuurimõis: 01.12.–31.01.2012.

The best pictures from the competition of computer drawings made in 2009 were also exposed:

- Nõo Library, Tartu County: 21.02.–22.03.2011.
- Waide Motel, Tartu County: 09.05.–31.12.2011.

U. Veismann continued the development of (Estonian) space terminology, the Estonian-English-Estonian dictionary is available at the website *www.aai.ee/eterkosm/*.

Numerous popular-scientific articles by our scientists are presented on the page 81, public lectures and interviews on the page 109.

The 88th issue of the Calendar of the Observatory was published as well as traditional Calendar of the Starry Sky.

2.7 Acknowledgements

Many associates were supported by various institutions throughout the world. Herewith we cordially thank:

- Archimedes Foundation
- ASTRONET (EC FP7 project)
- Astronomical Institute of the Academy of Sciences of the Czech Republic
- Astrophysikalisches Institut Potsdam
- Estonian Academy of Sciences
- Estonian Ministry of Education and Research
- Estonian Ministry of Environment
- Estonian Ministry of Finance
- Estonian Science Foundation
- Enterprise Estonia
- Euro–Asian Astronomical Society
- European Astronomical Society

- European Commission
- European Space Agency
- Helsinki University
- Instituto de Astrofisica de Canarias
- International Astronomical Union
- Institute of Physics, University of Tartu
- Nordic Forest Research Co-operation Committee (SNS)
- Nordic Optical Telescope
- Observatori Astronomic, Universitat de València
- Ondřejov Observatory
- Oulu University
- Pakker Avio
- Swedish National Space Board
- Tuorla Observatory, University of Turku
- University of Tartu
- World Radiation Center

3 Dark Energy, Dark Matter and formation of structure in the Universe Tumeenergia, tumeaine ja struktuuri teke Universumis

Kosmoloogia alal uuriti nii kosmoloogia põhiküsimusi (tumeaine ja tumeenergia omadusi, inflatsioonist tulenevaid järeldusi) kui ka suuremastaabilise struktuuri teket ja arengut Universumis. Struktuuri arenguga kaasneb galaktikate ja nende koosluste (galaktikagruppide, galaktikaparvede ja superparvede) teke ja areng – nende praeguste omaduste uurimine lubab teha järeldusi mineviku kohta.

Inflatsioonilise paradigma (Universumi esialgse ülikiire laienemise) kontrollimiseks uurisime inflatsiooniteooria ennustatud barüonostsillatsioonide (BAO) vaatluslikke ilminguid ja nende omadusi. Olime eelmisel aastal pakkunud välja võimaluse, et barüonostsillatsioonide jäljed võiksid olla fossiilidena säilinud praeguses galaktikajotuses. Sel aastal täpsustasime lainikmeetodit, mille olime esitanud varem, hindasime uuesti avastatud struktuuride usaldusväärsust ja alustasime leitud BAO kerakihtide detailset uurimist. Kuna BAO fossiilid on väga sarnaste omadustega, saab neid uurida, kombineerides formaalselt üksikuid struktuure omavahel; see tõstab oluliselt tulemuste täpsust. Täpsed vaatlused nõuavad aga täpsemat teooriat; juba praegu näib, et vaadeldud BAO kerakihid on tunduvalt paksemad kui ennustatud. Üks saladuslikumaid Universumi koostiosi on tumeenergia, mis määrab kõige suuremate struktuurielementide, galaktikate superparvede ja suurte tühikute tekke ja arengu. Nende ehituse detailne uurimine lubab kontrollida erinevaid tumeenergia teooriaid.

Me analüüsisime Sloani ülevaate superparvede kataloogi enam kui kolmekümne rikkama superparve morfoloogiat ning pakkusime välja superparvede morfoloogilise klassifikatsiooni, mille järgi superparved jagunevad nelja põhitüüpi: ämblikud, mitmikämblikud, filamendid ja mitmeharulised filamendid. Näitasime, et piklikumad superparved on ühtlasi ka suurema heledusega, rikkamad ning keerulisema sisemise morfoloogiaga. Superparvede morfoloogilist mitmekesisust teooria (numbrilised simulatsioonid) praegu veel korralikult ei seleta. Uurisime seoseid superparvede füüsikaliste ja morfoloogiliste omaduste vahel peakomponentide analüüsi abil ning näitasime, et superparvede omadused on tugevalt korreleeritud. Tuletasime seose rikaste superparvede mõõtmete, kuju ning heleduse vahel. See seos lubab tulevikus kontrollida struktuuri arengu teooriat.

Jätkasime superparvede võrdlemist Plancki missioonist saadavate reliktkiirguse omadustega. Esimesed tulemused superparvede ja SZ-efekti seostest on juba ilmunud Plancki missioonile pühendatud ajakirja "Astronomy and Astrophysics" erinumbris, töö aga jätkub. Olime juba mitu aastat otsinud seoseid galaktikate suuremastaabilise heledustiheduse ja galaktikatevahelise gaasi poolt põhjustatud reliktkiirguse spektrimoonutuste (SZ-efekti) vahel; sel aastal hakkasid lõpuks simulatsioonid loodetud tulemusi andma. See seos on oluline nn "kadunud barüonide" otsimiseks, mis võiksid asuda galaktikatevahelises ruumis, aga mida on seal väga raske näha. Kalibreerisime simulatsioonide põhjal otsitud seose ja alustasime Plancki missiooni esialgsete kogutaeva SZ-kaartide uurimist. Nagu öeldud, saab tumeenergia kohta järeldusi teha suurte mastaapide kohta käivate vaatluste ja vastavate mudelite võrdlemisel. Me jätkasime numbriliste suuremastaabilise struktuuri mudelite arvutamist, et uurida galaktikasüsteemide teket, ja analüüsisime saadud mudeleid.

Uurisime suurte lainepikkustega lainete mõju kosmilisele võrgustikule, superparvede ja tühikute rikkusele ja tühikute omadustele. Kui on olemas ainult väikese lainepikkusega tiheduslained, tekivad tihendid igal pool, aga nad on väga nõrgad. Kogu kosmilise võrgustiku tekkeks on oluline pideva tihedushäirituste spektri olemasolu, kus suurema lainepikkusega häiritused võimendavad väiksema lainepikkusega häiritusi lainete maksimumide piirkonnas (superparved, filamendid) ja suruvad alla väiksema lainepikkusega häiritusi pikkade lainete miinimumi lähedal (kosmilistes tühikutes). Selline erineva lainepikkusega tiheduslainete maksimumide ja miinimumide sünkroniseerimine on tiheduslainete arengu oluline tegur, mis tekitab esialgsest juhuslikust tihedusväljast vaadeldava kosmilise võrgustiku.

Teiseks oluliseks Universumi komponendiks on tumeaine, mis praeguste ettekujutuste järgi koosneb erilistest elementaarosakestest. Millised need osakesed on, pole aga veel teada. Me uurisime võimalusi, kuidas reliktkiirguse vaatluste abil saab kontrollida erinevaid teooriaid tumeaine kandjate kohta ja saime vastavad piirangud nii praeguste andmete (WMAP) kui ka uute ja alles planeeritavate kosmoseprojektide jaoks. Võrdlesime neid ka maapealsete kiirendite (Tevatron) võimalustega.

See on meile uus ja alles arenev temaatika. Jätkasime ka tumeaine uurimist juba harjunud moel, koostades galaktikagruppide katalooge ja uurides gruppide omadusi; neis domineerib tumeaine, mis grupid koos hoiab. Uuendasime oma Sloani ülevaate grupikataloogi ja lõpuks saime kätte 2MASS galaktikate kauguste kataloogi, mis lubas ka selle ülevaate grupid leida. Viimane ülevaade on unikaalne, kuna see katab pea kogu taeva.

Üks meie traditsioonilisi uurimissuundi on galaktikate tekke ja evolutsiooni uurimine. Sel aastal uurisime aktiivse tuumaga galaktikate asukohti superparvede võrgustikus. Leidsime, et Seyferti galaktikad, raadiokiirguseta kvasarid ja BL Lac objektid paiknevad põhiliselt väikese tihedusega piirkondades, raadiogalaktikad aga seal, kus keskmine tihedus on suur. Galaktikate aktiivsus näib sõltuvat nende suureskaalalisest ümbrusest, aga pole veel selge, miks.

Jätkasime kääbusgalaktikate spektraalvaatlusi Hobby-Eberly 11m teleskoobiga (Texas) valitud lähedastes galaktikagruppides. Lähedased grupid on ainuke koht, kus kääbusgalaktikaid näha, samas on neid aga gruppides palju ja nende seos grupi omaduste ja tekkelooga veel ebaselge.

Jätkasime meie naabergalaktika M31 struktuuri ja kosmilise tolmu omaduste uurimist, kasutades parimaid saadaolevaid vaatlusi optilises (SDSS) ja infrapunases (Spitzer) lainepikkuste vahemikus. Selle galaktika lähema ja kaugema külje heledusjaotuse ja eeldatava neeldumise võrdlus näitas, et kas M31 ei ole telgsümmeetriline või on sealne tolm Linnutee omast erineva koostisega.

Kõige rohkem vaatlusandmeid on meil oma kodugalaktika kohta. Selle ehitust ei saa me aga uurida samuti kui naabergalaktikaid, sest asume ise Galaktikas. Meie Galaktika uurimine toimub põhiliselt tähekoosluste baasil, kasutades statistilisi meetodeid. Siin on oluline täheülevaadete täpne statistika, nn tähtede klassifikatsioon. V. Maljuto täpsustas oma meetodit ülihiidude värvusindeksite määramiseks ja koostas uusi ja paremaid katalooge, mis sisaldavad eri metallilisusega tähti. See töö on oluline tulevase kosmosemissiooni Gaia andmete interpreteerimisel.

Me leidsime juba varem meie Galaktikas väga külmi vesinikupilvi. Sel aastal võrdlesime neid pilvi Plancki missioonis avastatud külmade gaasipilvedega; need näivad koos meie pilvedega moodustavat ühise populatsiooni, mille edaspidine areng viib tähetekkele. Aga selliste pilvede teke ja säilimine Galaktikas pole sugugi selge.

3.1 Testing the cosmological paradigm

The present cosmological paradigm includes the (already old and established) Big Bang scenario and three more recent components – dark matter, dark energy, and the initial rapid expansion (inflation). We worked on exploring all three ideas.

3.1.1 Testing inflation by baryon acoustic oscillations

Baryon acoustic oscillations (BAO) are present in the early Universe, before recombination, and are governed by the interplay between the gravitational pull of dark matter and the enormous pressure of the photon-electron plasma. These oscillations leave present-day observable traces in the galaxy distribution. So far these traces have been found, using statistical two-point descriptors. Our Spanish-French-Estonian team (Pablo Arnalte-Mur, Antoine Labatie, Nicolas Clerc, Vicent Martínez, Jean-Luc Starck, Marc Lachièze-Rey, Enn Saar, Silvestre Paredes) proposed to search for real remnants of BAO shells, using a specially developed wavelet template.

The BAO shells are huge, with the radius about 150 Mpc, and their density is small. Nevertheless, we proved that it is possible to discover them in the numerical models of the present-day Universe, and found clear traces of BAO shells in the Sloan Digital Sky Survey data. The paper has been accepted for publication in "Astronomy and Astrophysics". This work formed also part of Pablo Arnalte-Mur's (Valencia) PhD dissertation.

As the BAO shells trace real structures, we can study them in detail by choosing the best ones and combining them. This procedure is called 'stacking'; we have started working on

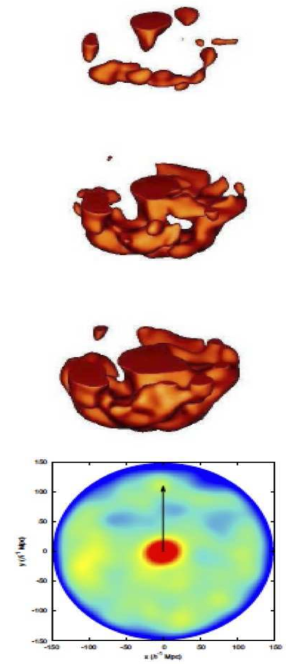


Figure 3.1: The stacked 3D and 2D density field of the observed BAO shells. In the top three panels, we show a smoothed 3D density at the levels of 1.10, 1.15, 1.25 mean density. A 2D slice of this density field is shown in the bottom panel. The arrow marks the BAO shell radius we measure, 109.5 Mpc/h. Summeeritud BAO kestade tihedusväljad. Kolmel ülemisel paneelil näitame silutud summeeritud tihedust nivoodel 1.10, 1.15 ja 1.25 keskmist tihedust. Alumine paneel näitab tiheduse lõiget; nool märgib leitud BAO kesta raadiust, 109.5 Mpc/h.

that, and we have clear ideas how to proceed.

G. Hütsi in collaboration with A.J. Hawken, F.B. Abdalla and O. Lahav (UCL, London) investigated the prospects of using the BAO scale as a feature of known physical size in the pattern of the galaxy distribution for breaking the degeneracy between geometric (Alcock-Paczynski) and dynamic (redshift space) distortions. Assuming that the BAO scale can be calibrated with an accuracy of $\sim 1\%$, using the precise measurement of the equivalent feature in the CMB, it was shown, using Fisher matrix analysis, that error ellipses for the line-of sight and tangential distortion parameters shrink by a factor of two for a $20(\mathrm{Gpc/h})^3$ "DESpec/BigBOSS"-like galaxy survey. The improvement turned out to be even more marked in smaller surveys.

G. Hütsi together with J. Chluba (CITA, Toronto), A. Hektor and M. Raidal (NICPB, Tallinn) calculated constraints on weakly interacting massive particle (WIMP) annihilation cross sections using the Cosmic Microwave Background (CMB) temperature and polarization measurements from the WMAP space mission.

The predictions for the Planck and ideal (cosmic variance limited) CMB experiments were also made. Particular attention was given to the WIMPs with masses $\sim$10 GeV, which have recently been claimed to be consistent with the CoGeNT and DAMA/LIBRA direct detection experiment results, while also providing viable dark matter (DM) candidates to explain the measurements of the Fermi and WMAP haze.

It was shown that the CMB signal of DM annihilations is independent of the details of large-scale structure formation, of the distribution and density profiles of DM haloes and other cosmological uncertainties. The bounds on all particle physics models of DM annihilation can be effectively described with only one parameter, the fraction of energy carried away by neutrinos in DM annihilation. They demonstrated that thermal relic DM in the CoGeNT, DAMA/LIBRA favoured mass range is in a serious conflict with the present CMB data for the annihilation channels with few neutrinos, and will definitely be tested by the Planck mission for all possible DM annihilation channels.

G. Hütsi participated in a joint project with NICPB (Tallinn) investigating in detail the consequences of the model by Isidori and Kamenik that is claimed to explain the top quark forward-backward asymmetry at Tevatron, to provide the GeV-scale DM, and to improve the agreement between the data and theory in the Tevatron W+jj events. By computing the DM thermal relic density, the spin- independent DM-nucleon scattering cross section, and the CMB constraints on both the Dirac and Majorana neutralino DM in the parameter space that explains the top asymmetry, they demonstrated that a stable light neutralino is not allowed unless the local DM density is 3-4 times smaller than expected. In that case the Dirac DM with the mass around 3 GeV may be possible, and that possibility will be finally tested by the Planck CMB mission.

G. Hütsi also participated in a collaborative project (M. Cirelli, G. Corcella, A. Hektor, M. Kadastik, P. Panci, M. Raidal, F. Sala, A. Strumia) aimed to provide ingredients and recipes for computing signals of TeV-scale Dark Matter annihilations and decays in the Galaxy and beyond. For each DM channel, the energy spectra of particles at production, computed by statistically reliable simulations, were presented. The Monte Carlo uncertainties of those input spectra were estimated by comparing the equivalent results from the Pythia and Herwig event generators. The propagation functions for charged particles in the Galaxy, for several DM distribution profiles and sets of propagation parameters were calculated. The energy spectra of $e^{\pm}$, $\bar{p}$ and $\bar{d}$, gamma ray fluxes (both from prompt emission and from Inverse Compton scattering in the Galactic halo) at the location of the Earth along with extragalactic gamma ray spectra were all provided in easily usable numerical form.

3.2 Superclusters

Superclusters are the largest elements of the cosmic web. As they are large, their evolution is not over yet, and they carry the memory of the initial conditions (in the early Universe). We compiled supercluster catalogues for the SDSS DR7 data, and studied the properties of the best-observed superclusters in the Sloan Great Wall.

3.2.1 The morphology and galaxy populations of the Sloan Great Wall superclusters

We used the data from the Sloan Digital Sky Survey (SDSS) to continue the study of the morphology of superclusters. We used the catalogue of superclusters compiled by L.J. Liivamägi and studied the morphology of the largest known galaxy system – the Sloan Great Wall (hereafter SGW) and its member superclusters. We characterized the clumpiness and the shape of the SGW using the fourth Minkowski functional and the morphological signature (in the shapefinders plane).

To calculate the Minkowski functionals we at first reconstruct the density field of galaxies. There are two main effects that affect the reconstructed density field and its Minkowski functionals. The first is due to the fact that about 6– 7% of galaxy redshifts are missing, because of fiber collisions. About 60% of these missing galaxies are probably located approximately at the same distance as their close neighbours. We found the collision groups in the SDSS, determined the galaxies that do not have redshifts because of fiber collisions, and ran Monte-Carlo simulations, assigning to 60% of randomly selected non-redshift galaxies the redshift of their neighbours. Other 40% of non-redshift galaxies were omitted, assuming that their true redshift will take them out of the supercluster. We ran 1000 simulations and found that both the morphological signatures and V_3 did not change (at the 95% confidence level) – fiber collisions are too scarce to affect the estimates of the morphological characteristics. Another effect is the discreteness of galaxy catalogues (shot noise) that induces errors in the density estimates. To take this into account we have to define first the statistical model for the spatial distribution of galaxies within a supercluster. One possibility is to use the Cox model, where we have a realization of a random field and a Poisson point process that populates the supercluster by dropping galaxies there with the intensity proportional to the value of the field. We tested that model and found that it is not able to describe the structure of superclusters. Then we used the popular halo model ideology to define a statistical model for superclusters. We assume that a supercluster is defined by its dark matter haloes, and discreteness errors are caused by random positions of galaxies within these haloes. As the halo model assumes that the main galaxy of a halo lies at its centre, the main galaxies of our groups and the isolated galaxies (the main galaxies of haloes where other galaxies are too faint to be observed) remain fixed. For satellite galaxies, we use smoothed bootstrap to simulate the distribution of satellites inside our haloes – we select satellite galaxies by replacement, and add specific shifts to their spatial positions. This procedure led to meaningful confidence intervals for the morphological descriptors.

3.2.2 The morphology of a large sample of superclusters from the SDSS

The study of the morphology of superclusters gives us information about the properties of superclusters and the cosmic web. Morphology is one aspect of the environment for galaxies and galaxy systems in them. The comparison of the morphology of observed and simulated superclusters is a test for cosmological models. M. Einasto, E. Saar, J.L. Liivamägi together with E. Tago, E. Tempel, V. Martínez from Valencia University, P. Heinämäki from Tuorla Observatory and J. Einasto studied the morphology, as well as the cluster content and the large scale distribution of a large sample of superclusters from the SDSS.

Superclusters in our sample form three chains of superclusters, the richest of them being the Sloan Great Wall. These chains and several rich superclusters, the well-known Corona Borealis supercluster among them, form the Dominant supercluster plane, described earlier by us using data about superclusters of Abell clusters. We used the fourth Minkowski functional V_3, the shapefinders K_1 and K_2, the morphological signature (in the shapefinders $K_1 - K_1$ plane) and the shape parameter (the ratio of the shapefinders for the whole superclusters) to characterize the morphology of superclusters.

Using multidimensional normal mixture modelling we showed that superclusters can be divided into two sets according to their shape parameter. Richer and more luminous superclusters are also more elongated and have more complicated inner morphology than poor, less luminous superclusters. Individual superclusters can be morphologically described as spiders, multispiders, filaments and multibranching filaments. Different morphologies of superclusters suggest that their evolution has been different. At present simulations do not explain the morphological variety of the observed superclusters. M. Einasto, J.L. Liivamägi, E. Saar, E. Tempel, J. Einasto, E. Tago and V. Martínez from University of Valencia used principal component analysis to study relations between the physical and morphological properties of superclusters from the Sloan Digital Sky Survey. They found that the properties of superclusters are strongly correlated. They showed already in an earlier study that richer superclusters are more elongated and have more complicated inner structure than poor superclusters, but so strong correlations as found now were unexpected. Two first principal components take into account more than 90% of the variance in supercluster properties and define the fundamental plane of superclusters – superclusters are simple objects which can be described with a small number of parameters. They used principal component analysis to derive scaling relations between the luminosities, sizes, and shapes of superclusters in the fundamental plane. Superclusters can be divided according to their shapes into two populations with different scaling relations.

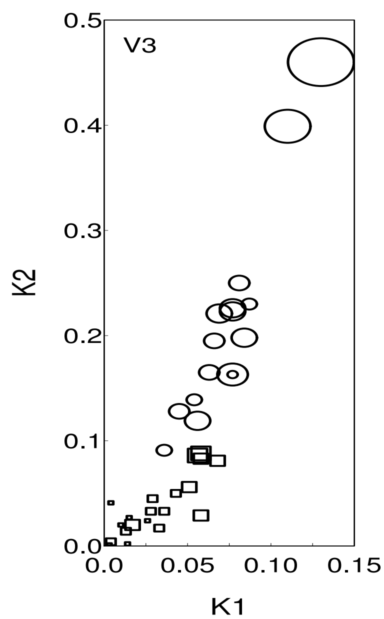


Figure 3.2: The shapefinders K_1 (planarity) and K_2 (filamentarity) for the superclusters from the SDSS. The symbol sizes are proportional to the fourth Minkowski functional V_3; the larger it is, the more complicated is the structure of the supercluster. Ellipses denote more elongated superclusters and squares denote less elongated superclusters. Kujukirjeldajad K_1 (lapikus) ja K_2 (piklikkus) SDSS superparvede jaoks. Märkide suurus on võrdeline neljanda Minkowski funktsionaali väärtusega; mida suurem on V_3, seda keerulisema ehitusega on superparv. Ellipsid tähistavad piklikumaid ja ruudud vähem piklikke superparvi.

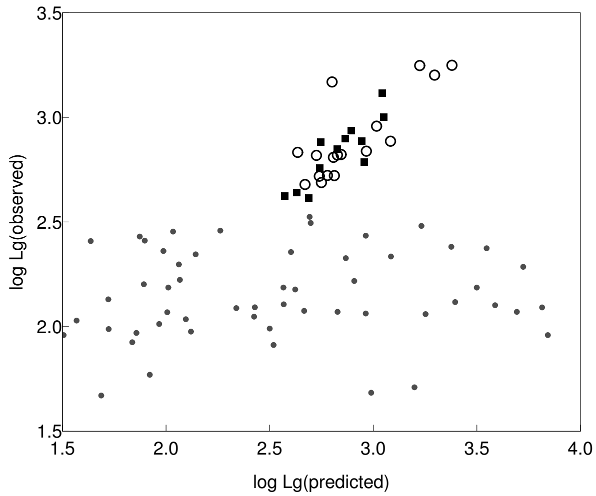


Figure 3.3: The relation between the observed and predicted luminosities of superclusters. Predicted luminosities are calculated from the data on shapes and diameters of superclusters, using principal component analysis. Circles denote more elongated superclusters and squares denote less elongated superclusters. Points correspond to small, Local Supercluster type superclusters of spider morphology with one rich cluster and outgoing filaments. For them, the shapes are not well defined and the scaling relation cannot be derived. Seos superparvede vaadeldud ning kujukirjeldajate ja läbimõõtude kaudu arvutatud heleduse vahel, mille tuletamiseks kasutasime peakomponentide analüüsi. Ringid tähistavad heledaid piklikumaid ja ruudud vähem piklikke superparvi. Punktid vastavad väiksema heledusega superparvedele, mille kuju on halvasti määratud (enamasti on tegemist Kohaliku Superparve tüüpi ühest rikkast parvest ja sellest väljuvatest galaktikakettidest koosnevate süsteemidega) ja seos superparvede kujude, mõõtude ja heleduste vahel puudub.

3.3 Clusters of galaxies

Galaxy clusters are the richest gravitationally bound galaxy complexes. They are easy to observe even at large distances, and the observational data on galaxy clusters is coming from optical, radio, X-ray spectra, and from gravitational lensing studies.

Clusters of galaxies form larger systems – superclusters of galaxies, and filaments which connect superclusters over huge voids to form a supercluster-void network. According to the current theories of the structure formation and evolution in the Universe systems of galaxies grow by hierarchical clustering driven by gravity. Signatures of multimodality (the presence of substructure, non-Gaussian velocity distribution and large peculiar velocities of the brightest galaxies) in galaxy clusters give us information about the dynamical state of these systems, and about the processes which shape clusters, galaxies in them and also about larger systems where clusters reside. M.

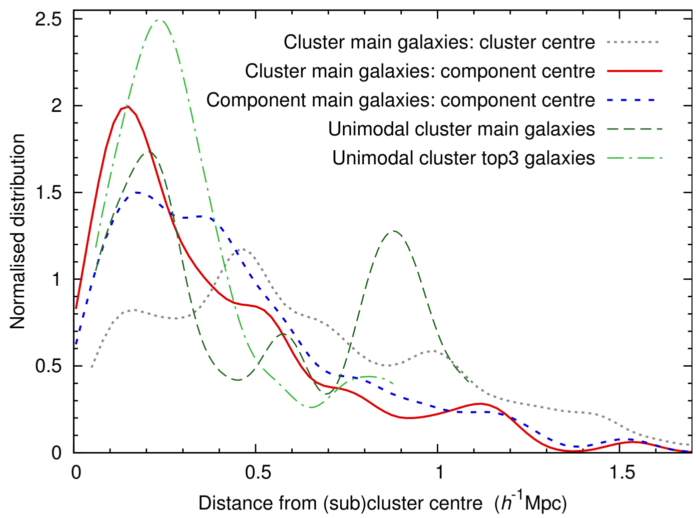


Figure 3.4: Cluster main galaxy distance from the cluster (subcluster or component) centre for various subsamples of galaxies. Multimodal clusters: Grey dotted line: the distance from the cluster centre for cluster main galaxies; red solid line: the distance from the (nearest) component centre for cluster main galaxies; blue dashed line: the distance from the component centre for the brightest galaxies in a component. Unimodal clusters: dark green long-dashed line: the distance from the cluster centre; light green dotted-dashed line: the minimal distance from cluster centre for the three brightest galaxies in clusters. Galaktikaparvede peagalaktikate kaugused parve (alamparve) tsentrist. Mitmekomponendilised parved: hall punktiir tähistab kaugust parve tsentrist, punane joon kaugust lähima komponendi tsentrist. Sinine kriipsjoon näitab kõige heledamate galaktikate kaugust selle komponendi tsentrist, kus nad asuvad. Ühekomponendilised parved: tumeroheline kriipsjoon tähistab peagalaktika kaugust parve tsentrist, heleroheline joon – kolme kõige heledama galaktika minimaalset kaugust parve tsentrist.

Einasto, J. Vennik, E. Tempel, E. Tago, E. Saar, L.J. Liivamägi and J. Einasto together with P. Nurmi, A. Ahvensalmi and P. Heinämäki from Tuorla Observatory and V. Martínez from Valencia University started the study of multimodality in the richest galaxy clusters from the SDSS. They used data about the richest systems from the group catalogue based on SDSS Data Release 8, compiled by E. Tago and E. Tempel together with their colleagues in the cosmology group. They employed a number of 3D, 2D, and 1D tests to search for substructure and for non-Gaussian velocity distributions in galaxy clusters, and analysed peculiar velocities and locations of the cluster brightest galaxies. Their preliminary results show that more than 80% of clusters have substructure. The main galaxies of groups are typically located near the centre of one component in a group, suggesting that they were the main galaxies in that component before smaller galaxy systems merged to form the cluster as we observe it now. These results indicate that galaxy clusters are dynamically young and still forming. The fraction of clusters with substructure in simulations is much smaller, and our results are also in conflict with the popular halo model of galaxy clusters, according to which the galaxies forming the cluster reside in a common dark matter halo, in which the brightest galaxy is also a central galaxy, and there is no significant substructure. Simulations made by P. Nurmi show that late time major mergers in simulated haloes lead to substructure in dark matter haloes similar to that found in observed rich clusters of galaxies.

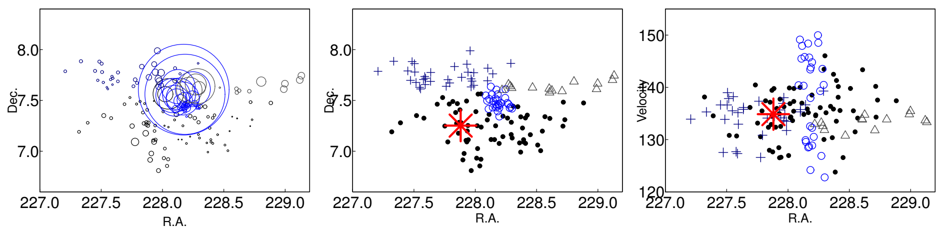


Figure 3.5: A rich multimodal cluster of galaxies from the SDSS (cluster 34726). The left panel shows the sky distribution of galaxies; symbol sizes are proportional to the probability to have substructure according to the Dressler-Shectman test. The middle and right panels show the sky distribution and the R.A. vs. velocity of galaxies in the cluster; here the red star indicates the location of the main galaxy, other colours correspond to different components determined by 3D normal mixture modelling. Rikas, mitmemodaalne galaktikaparv (34726). Vasakpoolne joonis näitab galaktikate jaotust taevas; märkide suurus on võrdeline alamstruktuuride tõenäosusega Dressler -Shectmani testi järgi. Keskmine ja parempoolne joonis näitavad galaktikate taevajaotust ja otsetõusu vs. galaktikate kiirused. Erinevad värvid vastavad 3D normaaljaotuste segu modelleerimisel leitud komponentidele, punane täht näitab peagalaktika asukohta.

3.4 Groups of galaxies

Galaxy groups contain much less galaxies than clusters, but are the main building blocks of the large-scale cosmic network.

3.4.1 Observed groups

E. Tago, E. Tempel and L.J. Liivamägi compiled galaxy group catalogues for the latest data release, DR8, of the SDSS. The SDSS DR8 contains redshifts for 929 555 galaxies; in order to avoid systematic errors, they carefully selected the data, leaving 576 493 galaxies for the group catalogue. They used the friends-of-friends method to define groups, and, as a result, found 77 858 flux-limited groups up to the redshift $z = 0.2$ in the SDSS area, covering about 25% of the sky. The catalogue has been submitted for publication and archiving, and has already served as the basis for several large-scale structure studies.

E. Tago compiled also a group catalogue for the 2MASS (Two Micron All Sky Survey). These galaxies have been observed in infra-red, are predominantly spirals and populate groups differently from the usual mix of elliptical and spiral galaxies. This catalogue is relatively shallow, reaching only up to the redshift $z = 0.1$, but it covers almost all the sky.

3.4.2 Groups in simulations

A group of cosmologists from Tuorla Observatory and Tartu Observatory lead by P. Nurmi from Tuorla compared the properties of galaxy groups in the Millennium simulation and the SDSS. The aim of this study was to test the hypothesis that real galaxy groups are galaxy systems hosted by a shared dark matter halo. For that they analysed in detail the statistical properties of galaxy groups in the SDSS galaxy group catalogue and mock catalogues. The comparison between simulations and observations reveal differences between the groups, based on the semi-analytical galaxy models, and the real galaxy group properties. They constructed three different mock galaxy group catalogues from the Millennium semi-analytical galaxy catalogue and studied how well these represent the real Universe described by the SDSS galaxy group catalogue by E. Tago and his colleagues, and compared the group luminosities, group richnesses, virial radii, maximum separations and velocity dispersion distributions. They found that the spatial densities of groups agree within one order of magnitude in all samples. There is a rather good agreement between the mock catalogues and observations for groups constructed in the same way in the simulations and in the observations. The distributions have similar shapes and amplitudes. However, semi-analytical methods create too many too bright galaxies. The comparison between the observed groups and groups with a common dark matter halo in simulations shows that only a small fraction of groups in the SDSS catalogue shows the existence of a common halo. The spatial distribution of galaxies in groups is different between simulations and observations. Beyond the virial radius of the group there are systematically more galaxies in the simulations than in the observations, although the agreement is good inside the virial radius.

3.5 General properties of the large scale structure of the Universe

3.5.1 Formation of the large scale structure and its wavelet analysis

J. Einasto in collaboration with Potsdam astronomers produced several series of numerical simulations of structure evolution of the Universe. These simulations have several goals: to investigate the influence of density perturbations of different scale to structure formation and evolution, the role of phases in the formation of systems of galaxies of various scales, the absence of galaxies in voids etc. Simulations were made for several cube sizes: 64, 100, 256, 500, 768 Mpc/h, and for resolutions of 256^3 and 512^3 particles and cells. For all models simulations were performed with the full power spectrum, and also with truncated spectra, where long-wave perturbations were cut at wavelengths of 16, 32, 64, and 128 Mpc/h. The initial conditions (the random numbers used to generate the initial positions and velocities of particles) were identical in models of various cuts; this allows to identify particles in systems (haloes), and to follow the behaviour of haloes in varying conditions.

Wavelet analysis of the models leads to the conclusion that the properties of the large-scale cosmic web depend on two important features of the evolution of density perturbations. The first feature is the synchronization of density waves of medium and large scales. Due to the synchronization of density waves of different scales, positive amplitude regions of density waves add together to form rich systems of galaxies, and negative amplitude regions of density waves add together to decrease the mean overall density in voids. Amplification of density perturbations is another feature of density evolution. Due to the addition of negative amplitudes of medium and large scale perturbations, the initial small-scale positive density peaks cannot grow in void regions. For this reason, small-scale proto-haloes dissolve there. In the absence of negative-amplitude medium and large-scale density perturbations, these peaks would contract to form haloes, which would also fill the void regions, i.e. there would be no void phenomenon as observed.

3.5.2 Statistics of the large-scale structure of the Universe

G. Hütsi in collaboration with T. Sato and K. Yamamoto (Hiroshima University) developed a fast Fourier transform based method for deconvolving the smearing effect of the survey window in the analysis of the multipole power spectra of galaxies. After testing the validity of the method with Monte Carlo mock catalogues, they applied it to the luminous red galaxy sample from the Sloan Digital Sky Survey Data Release 7.

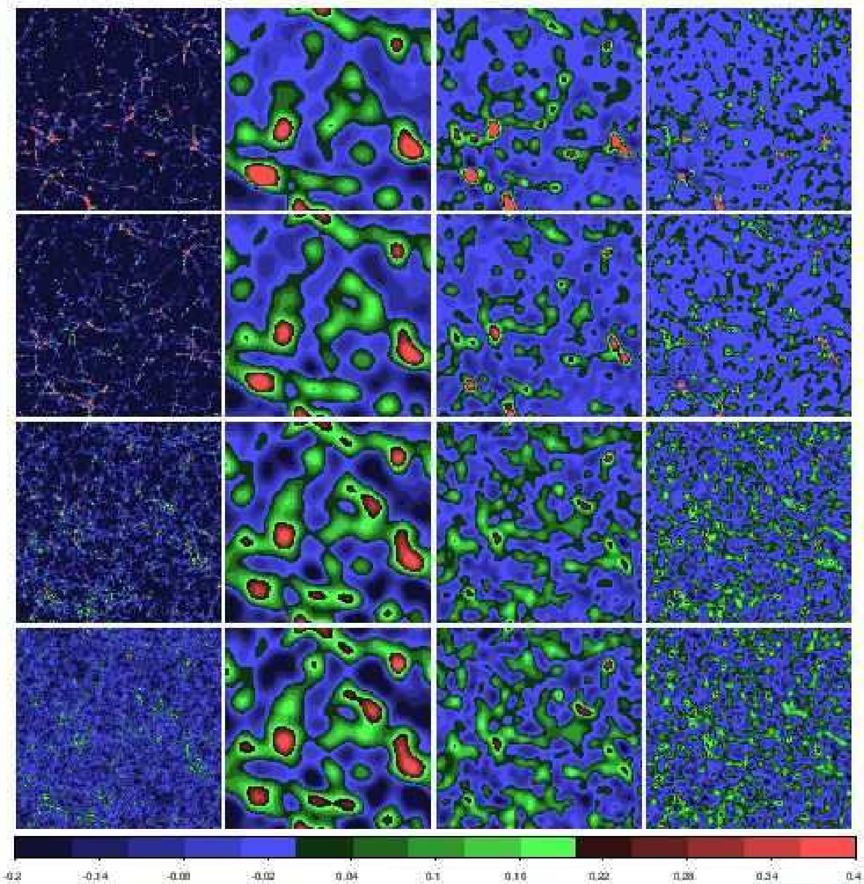


Figure 3.6: Slices of the high-resolution density field and its wavelet components from a numerical model of large-scale structure (for a cube of the size of 256 Mpc/h). The left column shows the density field, the next columns show wavelets of the scales 64, 32 and 16 Mpc/h. The upper row corresponds to the present moment (the redshift $z = 0$), and the lower rows – to the redshifts 1, 2, and 10. The colour scheme has chosen to keep the the same colours for all redshifts in the case of linear evolution. Green, yellow, red, and white show growing overdensities, blue indicates underdense regions. Struktuuri arengu numbrilise mudeli (kuubi suurusega 256 Mpc/h) suure lahutusega tihedusvälja ja lainikute 2-dimensionaalsed pildid. Vasakpoolses tulbas on toodud tihedusväli, järgmistes tulpades lainikud keskmise lainepikkusega 64, 32 ja 16 Mpc/h. Ülemises reas on toodud andmed praegusel momendil, mis vastab punanihkele $z = 0$, järgmistes ridades on pildid, mis vastavad varasematele arengumomentidele punanihetel 1, 2 ja 10. Lainikute kujutamisel on värviskaala valitud selliselt, et lineaarse arengu korral on värvid eri punanihetel samasugused. Roheline, kollane, punane ja valge värv tähistavad kasvava ületihedusega piirkondi, sinine värv alatihedusega piirkondi.

3.6 Studying the formation and evolution of galaxies

We studied the observational differences in the properties of present-day galaxies, in order to discover the possible paths of their formation and evolution. For that, we compared the properties of galaxies in different local (groups, clusters) and global (voids, superclusters) environments. The present galaxy formation paradigm (merger-dominated formation and evolution) explains well most of the dependencies we found, but we discovered also interesting discrepancies.

The differences in the morphology and galaxy content between the richest superclusters in the SGW suggest that these superclusters had different formation and evolution paths.

3.6.1 Nearby groups of galaxies

J. Vennik continued his studies of dwarf galaxies in a sample of local poor groups of galaxies. He searched the groups for new dwarf galaxy candidates and carried out follow-up spectroscopy of the highest rated dwarf galaxy candidates with the Hobby-Eberly telescope in collaboration with U. Hopp (Munich). They confirmed the group membership of about 20 newly detected dwarf satellites. According to their emission-line diagnostics, these are almost all actively star-forming dwarf irregulars. The surface photometry on the SDSS frames has shown zero or positive radial colour gradients, which could be interpreted as age gradients, indicating continuing star-formation preferentially near centre of (gas-rich) dIrr's.

J. Vennik and T. Kuutma (University of Tartu) studied the light and colour distribution of galaxies in nearby groups, to determine the radial dependency of stellar populations and to trace the star-formation history of galaxies in a group environment. They wrote an interactive image processing script, based on the MIDAS software, with interactive sky-background subtraction and image cleaning options. The members of two nearby groups around the NGC 3655 and NGC 6962 were studied in the optical (SDSS) and near-IR (2MASS) frames. The derived colours and colour gradients will be interpreted using stellar population models.

3.6.2 Our Galaxy

U. Haud continued the work with the HI radio data. This year the studies were carried out in three main directions. He continued the cluster analysis of the Gaussian decomposition of the Leiden-Argentina-Bonn (LAB) Survey. The aim was to separate the high- and intermediate velocity clouds (HVCs and IVCs) from the general database of the Gaussians. This yielded the first catalogues of HVCs and IVCs, compiled by the same method and based on a statistically more precisely specified definition of these objects (see Haud 2008). After obtaining the catalogues, a trial was made to estimate the distances of these clouds, using the method proposed by Haud (1990). Unfortunately, the results were very noisy and not of a great value.

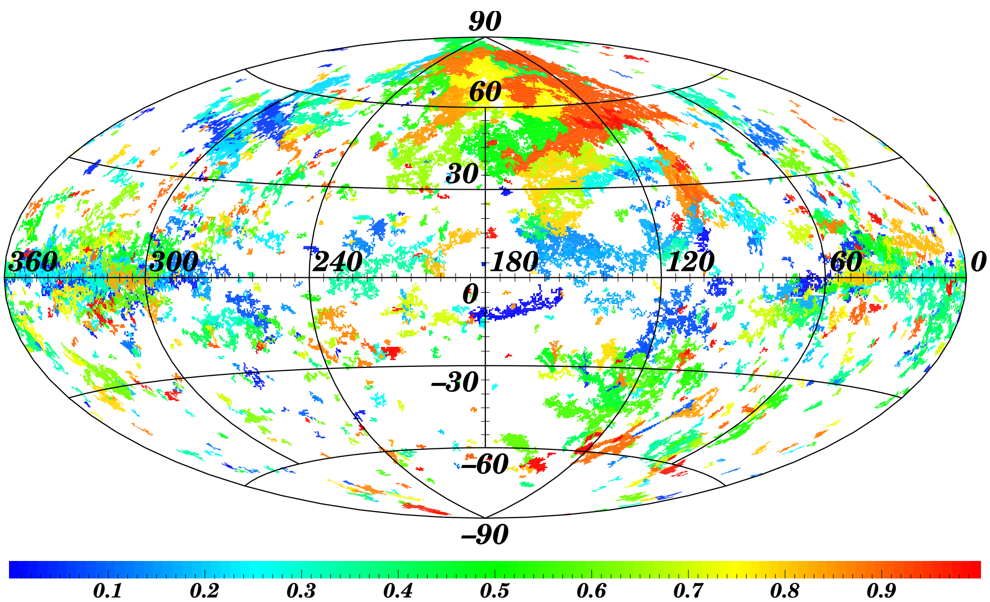


Figure 3.7: The all-sky map of IVCs. The colour scale represents the probability quantiles of the clouds to be identified as IVC. The most typical IVCs are red and the blue clouds near the confusion limit with other HI structures. IVCde kaart. Kõige tüüpilisemate omadustega pilved on punased ja sinised pilved, mis on oma parameetritelt teistest pilvetüüpidest peaaegu eristamatud.

In parallel with the continuing work with the LAB data, U. Haud started preparation for using the new Effelsberg-Bonn HI Survey (EBHIS). As the methods of observations of the LAB and EBHIS differ considerably, the new survey requires also substantial revisions in the Gaussian de-composition algorithm. This year U. Haud got acquainted with the main properties of the EBHIS, developed the basic ideas for changing the decomposition algorithm and visited the Argelander-Institut für Astronomie of the Bonn University to discuss these topics with the authors of the EBHIS.

In September the Tartu-Tuorla joint meeting "Remote sensing of the Universe" was held in Tartu. One topic of this meeting was the discussion of the recent results from the Planck mission. In this context a question arouse about the relation between the narrow-line HI emission (NHIE) features, studied by U. Haud in the recent years, and of the Planck cold clumps (CC), reported by the Planck Collaboration at the start of 2011. This question was now especially studied by U. Haud and the results were reported at the meeting. U. Haud has continued this research to demonstrate that the NHIE (which may be physically identical structures with the HI self-absorption (HISA) clouds in different observing conditions), the Planck CC and the Bok globules may be successive stages in conversion of the diffuse HI gas into the stars.

V. Malyuto continued development of classification methods for deep surveys of stellar populations in the Galaxy. Such methods are capable of extracting the main atmospheric parameters (effective temperature, gravity, metallicity) for large stellar samples from the available spectral and photometric data. The obtained parameters are used to investigate the structure and evolution of the Galaxy. A representative set of templates (stars with reliable parameters covering the whole HR diagram and metallicity range) is necessary to serve as calibration stars in classification. To increase the number of templates and to improve the data, V. Malyuto analysed some selected independent catalogues of effective temperatures for F-G-K stars of normal metallicity, determined the external errors of data for homogeneous subsamples through data intercomparisons and produced a preliminary mean homogenized catalogue of 800 stars with reliable effective temperatures.

Some recent published catalogues and new spectral libraries were added and treated with the same approach, their external errors of effective temperatures for some new subsamples were estimated. To apply the approach to the stars of low metallicity, V. Malyuto analysed selected catalogues containing metal-deficient stars, too. He plans to produce an extended homogenized catalogue of stars with reliable atmospheric parameters for using them as templates in classification.

3.6.3 Andromeda Galaxy

A. Tamm, E. Tempel and P. Tenjes continued studies of the structure of M31, and of cosmic dust in it. They used the best available data from the optical (SDSS) and infrared (Spitzer) surveys. They compared the luminosity distribution and the expected absorption from the near and far side of M31 and found that either this galaxy is not axisymmetrical, or its dust is different from that in the Galaxy.

They are continuing detailed analysis if light absorption in the cosmic dust, using also ultraviolet data (from the Galex mission), and the most recent observations in far infrared (from the Herschel Space Observatory).

4 Observational and theoretical investigation of stars and their envelopes during advanced evolutionary phases Evolutsiooni hilisfaasis tähtede ja nende ümbriste vaatluslik ja teoreetiline uurimine

Hilises evolutsioonifaasis tähtede hulgas leidub nii kuumi kui külmi tähti, samuti võib tegemist olla kaksiktähtedega. Kõigi nende sobitamine ühtsesse pilti koos vähem evolutsioneerunud tähtedega aitab paremini mõista tähtede evolutsiooni üldisi seaduspärasusi ja tähtede rolli Universumi evolutsioonis.

Jahedatest tähtedest jätkati post-AGB, vesinikuvaeste ja punaste ülihiidtähtede uurimist. Seekord oli põhjalikuma vaatluse all 89 Her, mis kuulub punaste ülihiidtähtede hulka. 89 Her osutus nõrgalt metallivaeseks täheks [Fe/H] ≈ -0.5. s-protsessis moodustuvate elementide sisaldused on selgelt defitsiidis, seega pole täht post-AGB evolutsioonistaadiumis. Arvukate nõrkade emissioonijoonte radiaalkiirustest järeldub, et tolmuketast vaatleme risti selle tasandiga.

T. Nugis ja K. Annuk analüüsisid kasutuselolevaid meetodeid interstellaarse, tähe lähiümbruse, intergalaktilise ja galaktikate lähiümbruse ekstinktsiooni määramiseks. Kogu ekstinktsioon koosneb lainepikkusest sõltuvast komponendist ja mitteselektiivsest komponendist. Viimase panus pole üldjuhul usaldusväärselt teada. T. Nugis ja K. Annuk töötasid välja meetodi mitteselektiivse ekstinktsioonikomponendi määramiseks, mis eeldab tähtede kauguste teadmist.

T. Nugis alustas väga suure massiga tähtede tuulte modelleerimist. Nende tähtede sisemused ületavad pealpool tuumapõlemistsooni kas täies ulatuses või osaliselt nn Eddingtoni heledust, mille puhul täht oleks dünaamiliselt ebastabiilne (ei suuda end koos hoida). Kui vaid osa tähe sisemusest ületab Eddingtoni piirheledust, siis suureneb aine äravool tähe väliskihtidest, kuid kui palju, pole täpselt teada. Varasemad väga suure massiga tähtede tuulte uuringud on põhiliselt käsitlenud vaid tuulte väliskihte, mis on optiliselt õhukesed (läbipaistvad) kontiinumis. Tuule omadused ja aine väljavoolu tekkepõhjus jäävad selle mudeli piires aga selgusetuks. Optiliselt paksu tuule mudeli korral kasutatakse hüdrodünaamilise tasakaalu kontseptsiooni ja ebastabiilsused süvakihtides mõjutavad tuule iseloomu ja parameetreid neis kihtides.

A. Sapar, A. Aret, R. Poolamäe ja L. Sapar jätkasid kuumade tähtede mudelatmosfääride arvutamist ning tähespektrite ja täheatmosfäärides toimuvate füüsikaliste protsesside uurimist. Aastal 2011 on tuletatud täpsemad analüütilised valemid vesiniku spektrijoonte profiilifunktsioonidele, mis kirjeldavad lineaarse Starki efekti, elektronide seotud-seotud siirete ja aatomite soojusliikumise koosmõju. Uued valemid võimaldasid täpsemalt ja vähema ajakuluga arvutada tähe mudelatmosfääre ja spektreid Fortran 90/95 tarkvara SMART abil kuumadele O, B ja A spektriklassi tähtedele peajadast ülihiidudeni. Selle mudelatmosfääride võrgu arvutamisel on oluliselt vähendatud ajakulu, moodustades mitmetuumaliste personaalarvutite kohaliku võrgu Python skripti baasil. Jätkus ka keemiliselt pekuliaarsetes HgMn täheatmosfäärides toimuva keemiliste elementide isotoopide difusioonilise separeerumisprotsessi füüsikalise pildi täpsustamine, arvestades mikroturbulentsi varasemast adekvaatsemalt.

A. Aret koos kolleegidega Tšehhi Vabariigist, Argentiinast ja Brasiiliast alustas ulatuslikku vaatlusseeriat uurimaks massiivsete tähtede (eelkõige B[e] ülihiidude) ketaste struktuuri, kinemaatikat ja tekkemehhanisme. Programmi esimesel etapil uuriti kaheksa Magalhãesi pilvedes asuva B[e] ülihiidtähe kõrglahutuslikke optilisi spektreid, mis saadi Euroopa Lõunaobservatooriumi 2,2-meetrise teleskoobiga. Neis spektrites on palju emissioonijooni, sealhulgas keelatud jooni, mis on optiliselt õhukesed ja seetõttu annavad väärtuslikku informatsiooni ketta ja tähetuule erinevate piirkondade kohta. Saadud tulemus ajendas alustama [Ca II] keelatud joonte otsinguid ka teiste tolmu- ja gaasiketastega ümbritsetud massiivsete tähtede spektrites. Ondřejovi 2-meetrise teleskoobi abil saadi 2011. aastal 63 tähe spektrid [Ca II] $\lambda\lambda$7291, 7324 Å joonte, Ca infrapunatripleti ja H_α piirkondades. Nimekirjas on B[e], Be, T Tauri ja FU Ori tüüpi tähed, Herbigi tähed ja kollased ülihiiud, millel kõikidel on tolmu ja gaasi ümbrised ja/või kettad.

A. Sapar esines konverentsil ülevaatega oma panusest kosmoloogiasse, näidates et mitmeid praegu aktuaalseid probleeme uuris ta juba palju aastaid tagasi. Ajavahemikus 1964–1976 avaldas ta Tartu Observatooriumi publikatsioonides mõningad artiklid, kus ta tuletas analüütilised üldistatud olekuvõrrandid homogeensele ja isotroopsele Universumile, mis on täidetud barüonainega ning sellest lahtisidestunud (decoupled) ning vaid gravitatsioonilises interaktsioonis olevate footonite ja seisumassi omavate neutriinodega. Ta näitas, et Universumi tumeenergia on käsitletav kui paisuva hüperboolse Universumi kineetiline energia, mis ületab kahekordselt Universumis sisalduva aine ja kiirguse potentsiaalse energia, millest ei jätku Universumi paisumise pidurdamiseks. Hüperboolne Universum käesoleval pikaaegsel epohhil siirdub oma arengus uude, kineetilise energia dominantsesse arengufaasi, mis avaldub Universumi kiirema evolutsioonilise paisumisena. Tumeaine võib aga olla mitterelativistlike seisumassi omavate neutriinode seisuenergia ($m_\nu c^2 = 4$ eV) foon.

Leitud valemite kohaselt toimub Suur Pauk aja nullmomendil ja Plancki ühikhetkeks saavutab Universumi karakteerne pikkuseskaala umbes 10^{-3} cm, mis ületab Plancki ühikpikkust umbes 10^{30} korda. Sellega kõrvaldub vajadus tuua sisse Universumi inflatsiooniline ekspansioon veidi hilisemal ajamomendil (10^{-35} s pärast Suurt Pauku). Just inflatsiooni on viimase kolme aastakümne jooksul peetud tegelikult Suureks Pauguks, kus kvantprotsesside tulemusena hüpoteetilisest ergastatud valevaakumist on kujunenud praktiliselt kogu aine Universumis.

Seega, alternatiivse evolutsioonikontseptsiooni kohaselt on Universumi füüsikalised põhikarakteristikud kujunenud ilma hüpoteetilise inflatsioonilise paisumiseta, Universumi paisumise kineetilise energia toel tumeenergia asemel ja neutriinofooniga tumeaine rollis.

V.-V. Pustynski jätkas kataklüsmieelsete kaksiktähtede heleduskõveraid modelleeriva arvutiprogrammi täiendamist. Uuriti kaaslastähe atmosfääri keemilise koostise avaldumist heleduskõverate iseärasustes. Alustati valgusreostuse uurimisprojekti Eestis, kus V.-V. Pustynski osaleb analüütikuna. Jätkati Apollo 11 kuupealse pildistiku fotogrammeetrilist uuringut, leides täpsustatud kaamerate ja objektide asukohad kuumooduli maandumisalas, identifitseeriti uusi maastikuobjekte, kasutades *Lunar Reconnaissance Orbiteri* uusi orbitaalpilte. Alustati Apollo 12 maandumiskoha fotogrammeetrilist analüüsi, määrates panoraamidealasid ja vastavate kaamerate asimuute.

ETF grandi toel algas uus projekt ülihiidude ja kuumade O ja B spektriklassi tähtede muutlikkuse uurimiseks (L. Leedjärv, T. Tuvikene, I. Kolka, T. Eenmäe, T. Liimets, doktorant J. Laur). Nelja aasta jooksul on plaanis leida heleduse muutumise ajaskaalad (mõnest päevast sadade päevadeni) vähemalt 100 tähe jaoks. Uudse vaatlusmeetodina kasutatakse kaugvaatlusi iTelescope. Net (varem GRAS) võrku kuuluvatel robotteleskoopidel, peamiselt USA-s New Mexico osariigis.

Alates 2011. aastast jätkab Tartu Observatoorium osalemist ESA kosmosemissiooni Gaia ettevalmistustöödes uue kolmeaastase (2011–2013) projekti "Kiirgusjoontega tähtede klassifitseerimine Gaia kataloogis" raames. Seda projekti rahastab ESA PECS (plaan Euroopa koopereerunud riikidele) programm. Esimesel aastal tegeldi maapealsete spektroskoopiliste ja fotomeetriliste tugivaatlustega ja nende analüüsiga. Gaia põhiprogrammi käivitamisele eelneb stardijärgse testimise periood, mil vaatluste põhipiirkonnaks on ekliptika poolusi ümbritsevad alad. Meie vaadeldud fotomeetriline aegrida (ca 50 vaatlusööd robotteleskoobiga New Mexicos USA-s) katab ekliptika põhjapooluse regiooni, kus oleme seni avastanud vähemalt neli muutlikku tähte ja hinnanud umbes 1000 objekti korral, millistes piirides võib nende heledust stabiilseks lugeda. Spektroskoopiliste tugivaatluste andmebaas sisaldab umbes 100 mitut tüüpi pekuliaarset tähte, nende hulgas ka kiirgusjoontega tähed. Meie ja Y. Fremat (Belgia Kuninglik Observatoorium) vahel alanud koostöö selgitab, kui suur on selle andmebaasi spektrofotomeetriline täpsus ja millised objektid sealt sobivad Gaia pekuliaarseteks standarditeks.

Kaksiktähtedest jätkati sümbiootiliste tähtede vaatlusi ja nende analüüsi.

Pearõhk oli suhteliselt palju uuritud tähel AG Dra, mille muutlikkuses tuleb aga ikkagi ette üllatavaid arenguid (L. Leedjärv, M. Burmeister). Jätkusid ka iseäralike tähtede V838 Mon ja GK Per uuringud (T. Liimets, I. Kolka, T. Kipper).

J. Pelt rakendas oma uudset kandevsageduse sobitamise meetodit magnetiliselt aktiivsete tähtede heleduskõverate analüüsil. Tulemused on paljutõotavad. Meetod võimaldab detailselt visualiseerida muutusi faasidiagrammides, eriti huvitavad on järsud, nn *flip-flop* sündmused. Jätkus ka ülikiire fotomeetria teoreetiliste aluste väljatöötamine. J. Laur kaitses sel alal oma magistritöö.

Üks huvitavaid probleeme kiirguslevis on leida footonite jaotusfunktsioon lennuteede pikkuse järgi, sest see võimaldab kirjeldada täheaine läbipaistmatust suhteliselt siledate funktsioonide abil. Kuna kiirguslevis optiline teepikkus esineb alati eksponentsiaalselt, siis on footonite lennuteede jaotusfunktsiooni leidmine seotud Laplace'i pöördteisendusega. Selle numbriliselt keeruka protseduuri üks lahendeid on antud Piessens-Huysmansi algoritmiga, mis aga nõuab kiirguslevi valemites footoni ellujäämise tõenäosust λ käsitlemist kompleksena. Sellega seoses töötas T. Viik välja kiirguslevi võrrandite lahendamismeetodi homogeense optiliselt lõpliku atmosfääri jaoks komplekse λ puhul.

I. Vurm koos kolleegidega Oulu Ülikoolist (A. Beloborodov ja J. Poutanen) uurisid kiirguslevi ultrarelativistlikes ainevooludes tingimustel, mis on omased gammasähvatustele. Nimetatud objektidest väljuva kiirguse spekter on superpositsioon ainevoolu erinevates osades aset leidvatest emissiooni ja neeldumis-/hajumisprotsessidest, mistõttu on oluline kiirguslevi korrektne arvessevõtmine. I. Vurm, A. Veledina ja J. Poutanen uurisid kõrge energiaga spektrite moodustumist aktiivsete galaktikate tuumades. Leiti, et vaadeldud kalgid röntgen- ja gammakiirgusspektrid Seyferti galaktikates võivad moodustuda relativistlike elektronide poolt kiiratava sünkrotronkiirguse pöörd-Comptoni hajumisel optiliselt tiheda akretsioonketta tsentraalosa kohal asuvas kuumas kroonis. Leitud kitsas spektraalindeksite jaotus laias parameetrite vahemikus on heas kooskõlas vaatlustega.

4.1 Late-type stars

The studies of post-AGB, hydrogen-deficient and luminous red stars were continued by T. Kipper. This year the spectrum of a post-AGB candidate, binary system 89 Her, was analysed for the chemical composition. The used spectra were obtained at the Canada-France-Hawaii Telescope (CFHT) with the echelle spectropolarimeter ESPaDOnS by Queued Service Observing team.

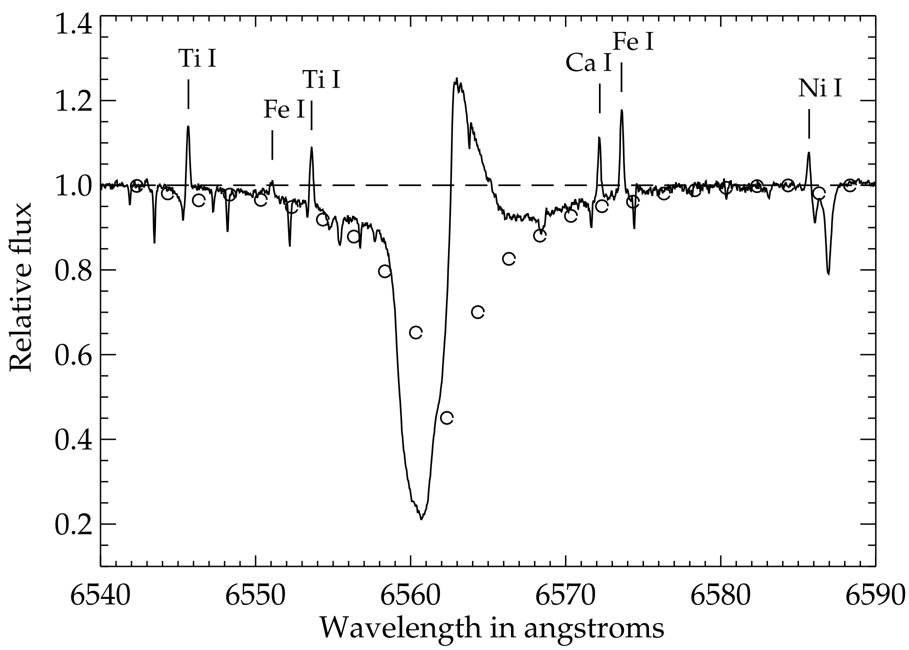


Figure 4.1: The Hα line observed on September 28, 2009. With the circles is denoted the synthetic profile calculated with the adopted metal deficient model (6600/0.8). The calculated profile is shifted according to stellar radial velocity. Some weak emission lines of neutral metals are also indicated. Hα joone profiil vaadelduna 28. septembril 2009. Ringikestega on tähistatud sünteetiline profiil, mis on arvutatud töös kasutatud metallivaese mudeli (6600/0.8) abil. Arvutatud profiil on nihutatud lainepikkustes vastavalt tähe radiaalkiirusele. On osutatud ka mõned neutraalsete metallide emissioonijooned.

The star was found to be slightly metal deficient with [Fe/H]=-0.50 ± 0.20 and does not show signs of AGB nucleosynthesis. The s-process elements are clearly underabundant. So, there is no s-process evidence for AGB nucleosynthesis and third dredge-up. The refractory elements are depleted but this is not the reason of metal deficiency. More than 320 narrow and weak emission lines from low levels of neutral metals were identified. Radial velocities of these lines coincide with the mean velocity of the system. We propose that the circum-binary dusty disk is observed face-on.

4.2 Hot luminous stars

T. Nugis in collaboration with K. Annuk overviewed the present methods of determination of the corrections of interstellar, circumstellar, intergalactic and circumgalactic extinction. The total extinction can be described as the sum of the wavelength-dependent and of the non-selective components. The wavelength-dependent component can be determined directly from the spectrophotometric observations, but the contribution of the non-selective component is presently not well known. They worked out the method for the reliable estimates of the the non-selective component of extinction which assumes the knowledge of correct distances to the stars (such data will become available after the measurements by the Gaia mission). T. Nugis in collaboration with H.J.G.L.M. Lamers (Utrecht University, the Netherlands) completed the study of modelling of optically thick winds of Wolf-Rayet stars and these results are in preparation for publication.

T. Nugis started the modelling of optically thick winds of the most massive stars. These stars have in their envelopes extended regions where the luminosity exceeds the Eddington limit L_{Edd}, i.e.: $\chi L/(4\pi c r^2) > GM/r^2 = \chi L_{\mathrm{Edd}}/(4\pi c r^2)$, where χ is the opacity, L is the luminosity, M is the mass, G is the gravitational constant and r is the distance from the stellar centre. If the stellar luminosity exceeds Eddington limit everywhere above the nuclear fusion zone, then such a star is dynamically unstable (the star could not hold itself together) and a strong outflow of stellar material results. The strong mass outflows are expected to result also in the cases when only a part of the stellar envelope exceeds the Eddington limit. Previous investigations of mass outflows from the most massive stars are mainly dealing with the optically thin (in continuum) parts of the envelope (atmosphere). Line driving due to the classical CAK-mechanism (radiation pressure force is enhanced due to the expansion of the atmosphere) is regarded to explain well their stellar winds. The structure of the wind at dense layers and the true cause of the matter outflow remains unexplained in these models. Dense parts of the envelope are usually regarded to obey the hydrostatic equilibrium (gradient of radiation + gas pressure balances the force of gravity). If the local luminosity in some point of the envelope exceeds the Eddington luminosity then respective layers become dynamically and convectively unstable (sometimes also pulsationally unstable). In the case of optically thick wind models the matter outflow is expected to originate in very deep layers and instead of the hydrostatic equilibrium it is needed to use hydrodynamical equilibrium concept everywhere in the envelope. Instability zones are modifying the structure of the wind in deep layers.

4.3 Stellar spectra and physical processes in stellar atmospheres

A. Sapar, A. Aret, R. Poolamäe and L. Sapar continued study and modelling of stellar atmospheres, stellar spectra and physical processes in stellar atmospheres.

In 2011 more precise formulae have been derived for the profiles of strong hydrogenic spectral lines, being dominating features in the spectra of hot stellar atmospheres. The line profiles of these spectral line series can be described by the triple integral which incorporates convolution of Holtsmark, Lorentz and Doppler profile functions. These functions describe the linear Stark effect in the statistical field of ions and electrons, bound-bound electron transitions and thermal motion of atoms respectively. The triple integral can be reduced to three single infinite integrals, weighed by sine and cosine, which are damped exponentially by the sum of corresponding three different ingredients. The analytical series expansions for different parameter values have been found in the terms of parabolic cylinder functions, connected with confluent hypergeometric series and Hermite polynomials. The analytical expressions reduce the number of independent parameters which enables better to understand resulting co-action of the physical processes and to formulate essentially more efficient software in stellar atmosphere modelling.

Corresponding software has been incorporated into the Fortran 90/95 software SMART. By its use a new set of hot model stellar atmospheres (O, B and A spectral type stars from main sequence to supergiants) and corresponding spectra have been computed. In addition, also a Doppler line profile, due to momentary nuclear 'kangaroo jumps' between different Stark field states, has been included into the line profile function. Its width has approximately the same value as the averaged Stark profile parameter. Presence of such an additional profile ingredient generates central plateaux of the spectral line profiles similarly to the model microfield method applied by C. Stehle for model stellar atmospheres. The model computations give essentially better spectrum for the regions of hydrogen spectral line series. The computations were carried out using a local network of parallel-processing multi-core personal computers of the working group. The Python script has been used as the shell language for connecting the slaves that computed the distributed parts of the spectra and the radiation flux, and of the master, computing the corresponding model corrections. To obtain the flux constancy about 0.3...0.1% throughout the whole computed atmosphere, up to 150 iteration loop steps were computed. The computations of the network were made using relative spectral resolution 30 000, the number of atmospheric layers 64, and the spectral range from 125 Å to about 50 000 Å, divided into 108 sections, having all the same relative width. Corresponding time consumption with 16 slaves was less than a hour. Further essential reduction of the time consumption can be obtained by applying the video charts for computation of the small but billions of times computed functions, say, of the integral-exponents in the radiative transfer. As an example, five computed spectral sections of main sequence star with $T_{\rm eff} = 12\,000$ K at transition from hydrogen Balmer line series to the correponding continuum is depicted in Fig. 4.2.

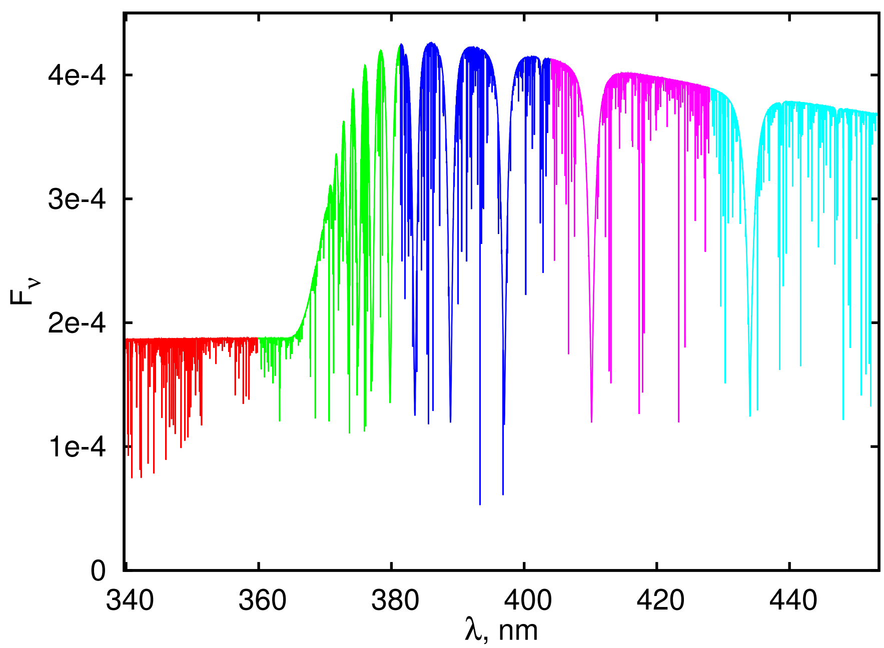


Figure 4.2: Five sections of spectra of main sequence star with $T_{\rm eff} = 12\ 000$ K at transition from Balmer line series to the Balmer continuum. The region is rich of spectral lines of different elements but dominated by those of hydrogen. Viis arvutatud spektrilõiku tugevate vesiniku Balmeri joontega B8 peajada tähe spektris. Kuigi selles piirkonnas leidub arvukalt mitmete keemiliste elementide jooni, domineerivad vesiniku jooned.

As an extension to the network of atmospheric models, also modelling of some hot white dwarfs atmospheres and their spectra has been carried out. The same was done for the supergiants very close to the Eddington luminosity limit. For these stars inclusion of upwards increasing microturbulence was obligatory to reduce the radiative drive to values lower than the gravity,.

The modelling of diffusive separation of the chemical elements and their isotopes in the quiescent atmospheres of mercury-manganese (HgMn) chemically peculiar (CP) stars has been continued. As a new feature the microturbulence has been incorporated into the light induced drift (LID) formulae. Such an improvement of the LID formulae gives essentially more realistic scenario of the characteristic diffusion time scale.

The LID phenomenon is planned to be applied also for study of white dwarfs. Compilation of the catalogue of spectral lines of calcium, taking into account isotope and hyperfine splitting is in progress. The study is aimed to explain the peculiar abundances of calcium isotopes in CP stellar atmospheres, based on the evolutionary diffusion scenarios due to LID.

In the framework of international collaboration with the Ondřejov Observatory (Czech Republic), A. Aret has participated in the observations and processing of emission-line rich Be star spectra. These stars have dense gaseous disks, where the emission lines are generated.

A. Aret started observational study of high-density discs around massive stars in collaboration with colleagues from the Astronomical Institute of the Academy of Sciences of the Czech Republic, Instituto de Astrofísica de La Plata, Argentina and Observatório Nacional, Rio de Janeiro, Brazil. The structure and geometry of discs around B[e] supergiants and their formation mechanism is hitherto unclair. Information on the density, temperature, and kinematics within the disc can be obtained from different sources like optical emission lines and molecular bands that trace different regions within the circumstellar material. Forbidden emission lines play hereby a very important role because they are optically thin and their profiles contain the full kinematical information on their formation regions. However, the lack of high-quality optical and near-infrared observations for most of the B[e] supergiants hampers a proper study of the structure and kinematics of both the atomic and molecular components within their discs.

Observational study, focused on the search for typical density and velocity tracers in the spectra of these stars, has been started. On the first stage of the program the high-resolution optical spectra of eight B[e] supergiants in the Magellanic Clouds were obtained, using the Fiber-fed Extended Range Optical Spectrograph (FEROS) attached to the 2.2-m telescope at the European Southern Observatory in La Silla (Chile).

A new set of valuable disc tracers – forbidden emission lines of [Ca II] $\lambda\lambda$7291, 7324 which supplement well-known disc tracers like the [OI] emission lines or the CO band emission – providing information about physically distinct regions within disc and wind, were discovered. This result inspired to start an extended survey of sources previously reported in the literature to possess emission in Ca II lines. Our sample consists of Herbig Ae/Be stars, T Tauri stars, Be stars, B[e] stars, and yellow hypergiants, all known to be surrounded by high-density disc- or shell-like structures. Observations have been carried out throughout the year using the Ondřejov 2-m telescope (Czech Republic). Spectra of 63 stars have been obtained in spectral regions of [Ca II] lines, Ca infrared triplet and Hα line. The observational data have been processed and already partially interpreted.

4.4 Luminous stars in stellar associations

A new four-year project, time-resolved survey of the most luminous stars in stellar associations and open clusters, was started in 2011 by T. Tuvikene, I. Kolka, T. Eenmäe, T. Liimets, and L. Leedjärv. In September, Ph.D. student J. Laur joined the project. The most luminous stars in this context are comprised of supergiants across the HR diagram, and O- to early B-type stars of all luminosity classes. The main aim is to find time scales of photometric variability of about 100 luminous stars, ranging from days to hundreds of days. This range has previously been poorly studied. Additionally, the brightest stars in open clusters have often been overexposed in deep studies. An observing programme of luminous stars thus requires frequent observations, using relatively small telescopes with large field of view. Commercial remotely operated telescopes equipped with research-grade photometric filters are most suitable for this purpose.

In March 2011, T. Tuvikene started remote observations using the telescopes in the GRAS (Global-Rent-A-Scope) network. Most of the observations have been carried out with the 250-mm GRAS-004 telescope in New Mexico, USA. During the first nine months (March–November), useful data were collected on 97 nights. Additional 12 observations of some southern targets were made with the 317-mm GRAS-009 telescope in Victoria, Australia. Observations with subsequent data reduction and analysis will continue in the coming years. Follow-up spectroscopic observations of the most interesting objects will be carried out with the 1.5-m telescope in Tõravere. A sample light curve of the red supergiant BI Cyg is shown in Fig. 4.3.

4.5 Preparations for the ESA Gaia mission

In 2011, the preparations for the Gaia space mission at Tartu Observatory have been continued in the framework of a new three-year (2011–2013) project "Emission line star classification in the Gaia Catalogue" which is financed by the ESA PECS (Plan for European Cooperating State) programme. According to this project the team at Tartu Observatory (L. Leedjärv, I. Kolka, T. Eenmäe, T. Tuvikene, K.Tinn) has started to measure and analyse the ground-based auxiliary spectroscopic and photometric observations needed

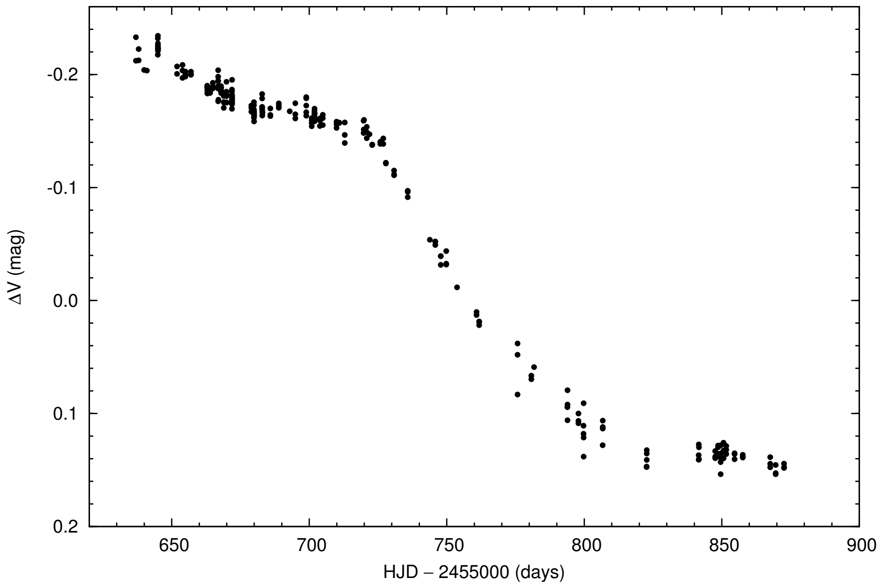


Figure 4.3: Differential V-band light curve of the red supergiant BI Cyg (March–October, 2011). Punase ülihiiu BI Cyg diferentsiaalne heleduskõver V-filtris (märts–oktoober 2011).

to select a sample of peculiar standard (template) stars to verify the identification and classification algorithms of these stars. The selected targets will be used during the whole Gaia working time, including the verification period when the two Ecliptic Poles regions will serve as test areas. In accordance with this task, the North Ecliptic Pole region has been monitored photometrically in V and Ic filters with a robotic telescope operating in New Mexico, USA. The preliminary analysis has revealed at least four variable stars, and determined the brightness stability limits up to ~ 1000 objects recognized in this field. In 2009, the spectra of ~ 100 peculiar stars have been observed in ESO by Y. Fremat (Royal Observatory of Belgium) to be used as the auxiliary database for Gaia. In cooperation with Y. Fremat the assessment of spectrophotometric quality of these observations is in progress, and the spectra of the subsample of 10 Wolf-Rayet stars have been reduced and analysed.

4.6 Symbiotic stars and related objects

In 2011, main emphasis was on the yellow symbiotic star AG Draconis. This star is considered to be a kind of classical symbiotic star, undergoing 1–2 magnitude outbursts in about one year time intervals and higher amplitude major outbursts in about every 13–15 years. Spectroscopic observations of AG Dra in Tartu Observatory started in 1997. The data collected up to now form an homogeneous 14 years long time-series, including a major outburst starting in July 2006 and several minor outbursts. L. Leedjärv and M. Burmeister analysed the variations of the strongest emission lines in the optical spectra of AG Dra: the hydrogen Balmer lines Hα and Hβ, the ionized helium line He II at λ4686, and the characteristic for symbiotic stars only line at λ6825, originating from Raman scattering of the O VI ultraviolet resonance line photons on the atoms of neutral hydrogen. In general, emission lines become stronger during the minor outbursts. Behaviour of the spectra in the major outburst is more complicated. While the hydrogen lines did not change much during 2006, the high ionization He II line λ4686 became significantly weaker, and the O VI λ6825 line practically disappeared. This indicates decrease in the temperature of the hot component. Another interesting event could be observed from July 2008 to March 2009 when all the named emission lines became remarkably weaker than usually, while there was nothing special seen in the light curves of AG Dra (the star was in quiescence without any outburst or fading). L. Leedjärv and M. Burmeister started to compare the variability of AG Dra with that of another classical (prototypical) symbiotic star Z And. General pattern seems to be surprisingly similar, while there are differences in the time scales of variations.

4.7 Peculiar stars

V.-V. Pustynski continued software elaboration for light curves of precataclysmic binaries. The manifistation of the companion star's chemical abundances in the light curve features has been investigated.

4.7.1 V838 Monocerotis

The photometric and spectroscopic monitoring of the peculiar binary star V838 Mon continued with the Nordic Optical Telescope (I. Kolka, T. Liimets, T. Kipper, and T. Augusteijn – NOT). The eclipse of the hot component is on-going also during the present observing period.

4.7.2 GK Persei

Multi-epoch images and spectra of GK Persei have been obtained to do detailed dynamical and morphological study of its nova remnant. The first results show that the nebula is a thick clumpy shell, with knots expanding with a range of speeds between 300 and 1000 km/s. Some knots have experienced slight deceleration since their ejection in 1901. The total luminosity of the nebula is fading, however several individual knots show significant brightness changes.

4.8 Time and frequency analysis of astronomical phenomena

J. Pelt proceeded with studies of magnetically active stars. He applied the new carrier fit method to the light curves of different magnetically active stars. Among the objects of the research program are such well-known objects as FK Com, II Peg, LQ Hya et al. The results are encouraging. This is the first time when use of appropriate interpolation scheme allows to visualize detailed changes in the phase diagrams of these stars. Of special interest are episodes when phase changes abruptly (so called flip-flop events).

Together with J. Laur from the University of Tartu, J. Pelt also developed statistical methods to study ultra fast photometric schemes. Progress report of these studies is given in the master dissertation successfully defended by J. Laur.

Estimation of time delays from a noisy and gapped data was another major research topic of J. Pelt (together with his students). Based on detailed review of the problems with earlier attempts to build time delay estimation algorithms, they developed a new automatic and robust procedure to perform the task. To evaluate and compare different variants of the algorithms they used real observational datasets. Of special interest were sets which have been objects of past controversies. In this way they were able to select the methods and procedures having highest probability to succeed in realistic complex situations. A. Hirv successfully defended his doctoral thesis on the time delays from light curves of gravitationally lensed quasars.

4.9 Radiative transfer

One of the most interesting problems in radiative transfer is finding the photons' path-length distribution function because it helps to describe the opacity of stellar matter with much more smooth functions. As far as the optical path appears in almost all functions connected with radiative transfer in an exponential factor, it is obvious that the photon path statistics is tightly connected with Laplace transforms, both direct and inverse. Finding an inverse Laplace transform numerically can be very complicated and there are a few algorithms which are suited to be used in radiative transfer. One of them is Piessens-Huysmans algorithm which demands the albedo of single scattering to be complex. Using the Chandrasekhar principles of invariance, T. Viik has elaborated a method to determine both the inner and outer complex ra-

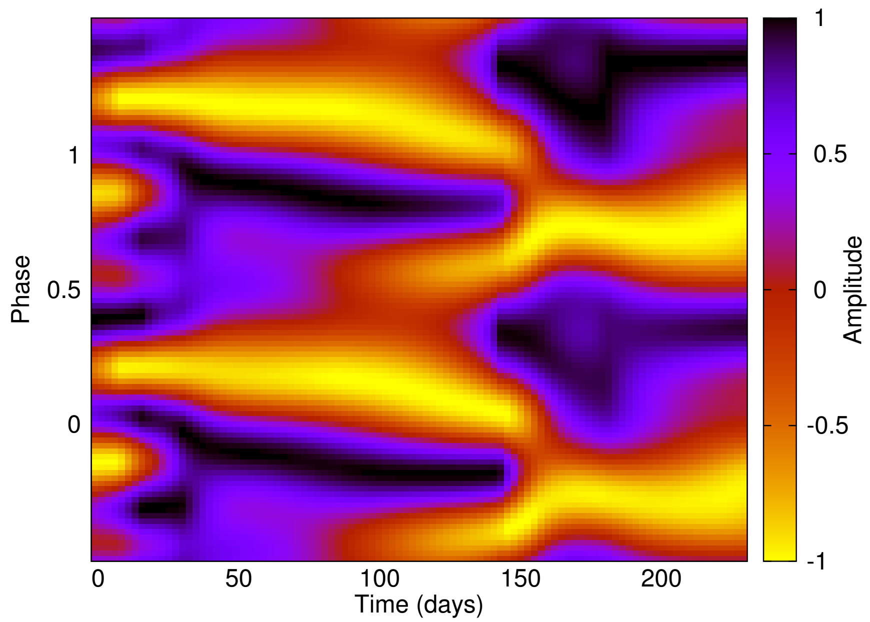


Figure 4.4: Flip-flop episode in the light curve of magnetically active star FK Com. The carrier fit method allows to build continuous time dependent phase curves. Flip-flop magnetiliselt aktiivse tähe FK Com heleduskõveras. Kandevsageduse sobitamise meetod võimaldab konstrueerida pidevaid ajast sõltuvaid faasikõveraid.

diation field for a plane-parallel homogeneous atmosphere together with the functions H, X and Y which describe the outer radiation field.

I. Vurm together with A. Beloborodov and J. Poutanen (University of Oulu, Finland) studied radiative transfer in highly relativistic jets under conditions characteristic of cosmological gamma-ray bursts (GRB). The emerging broadband spectrum from GRBs may be formed throughout both optically thin and moderately optically thick domains of the diverging outflow, making proper treatment of radiative transfer crucial. For numerical calculations they used the kinetic code developed by I. Vurm and J. Poutanen, adapted to relativistic flows. The simulations represent the first realization of accurate transfer calculations in a kinetic GRB code.

I. Vurm together with A. Veledina and J. Poutanen (University of Oulu, Finland) studied the formation of high-energy spectra from the nuclear regions of active galaxies, which may form in a qualitatively similar fashion to those in black-hole binaries and can be modelled by a hot inner accretion flow next to a cool optically thick accretion disk. Their simulations show that the observed hard X-ray/soft gamma-ray spectra of Seyfert galaxies with a cutoff at a few hundred keV are well represented by synchrotron self-Compton radiation from a hybrid (thermal/non-thermal) population of electrons. Their model predicts a narrow distribution of X-ray spectral slopes for a broad range of parameters, consistent with those observed in low ionization nuclear emission-line regions (LINER) and Seyferts at luminosities below 3% of the Eddington limit. They showed that the recently found correlation between the spectral slope and the Eddington ratio at higher luminosities can result from an increasing fraction of accretion disk photons entering the emission region, which can be associated with the decreasing inner radius of the accretion disk.

4.10 Lunar mapping

V.-V. Pustynski continued the photogrammetric study of Apollo 11 landing site features, more precisely locating sites of cameras and objects by the use of new orbital photos of Lunar Reconnaissance Orbiter. The photogrammetric analysis of the landing sites of Apollo 11 has been started, identifying the panorama areas and asimuths of corresponding cameras.

4.11 An alternative evolutionary scenario of the Universe

A. Sapar made a conference report where he reviewed his contribution to cosmology and showed that many of the presently actual problems (also those connected with the Nobel Prize of Physics 2011) were studied by him long ago. In a paper, published by him in Tartu Observatory Publications in 1964 and in some papers published in following years, A. Sapar derived a family of analytical generalized equations of state, the corresponding evolutionary scenarios of the uniform (homogeneous and isotropic) Universe, filled with baryonic matter and decoupled particles (photons and massive neutrinos) and also analytical formulae for several cosmological observables, especially for different distances and distribution functions.

All the three possibilities – the positive curvature (elliptic), the negative curvature (hyperbolic) and the flat Universe – were studied. In the equations of state it was taken into account, that in the expanding Universe the matter and the decoupled particles are only in the gravitational interaction. He also found that presence of the negative pressure component in the equation of state acts in the same way as the kinetic energy of expansion of the Universe.

The evolutionary scenario corresponding to the equations enables reasonably to carry out extrapolation back in time to the initial momentum of the Big Bang cosmology and to describe its evolution. Finding in the formulae the constants, specified from the presently observed values of the matter and radiation density, A. Sapar has shown that the dark energy in the Universe can be the kinetic energy of the expansion of the hyperbolic Universe, which exceeds more than twice the potential energy of all particles, having subcritical density. The hyperbolic Universe is presently in the beginning of its new evolutionary stage, the kinetic energy dominated epoch with quicker evolutionary expansion rate. The dark mass can be slowly moving rest-mass neutrinos (averaged rest energy about $m_\nu c^2 = 4$ eV). Similarly as in the case of parabolic Universe, with the critical density predominantly assumed by cosmologists, the problem of the nature of infinite initial Universe is not essentially elucidated.

The thermalized neutrino background has decoupled from the rest of particles, which were in the electromagnetic and strong interaction, when the age of the Universe was about 1 sec, i.e. at the age when the temperature of the expanding Universe was about 10^{10} K or the corresponding kinetic energy about 1 MeV, which corresponds to the rest energy of nucleons. Namely then thermonuclear synthesis of the primordial atomic nuclei started. The formulae for the detailed run of cooling of the decoupled uniform neutrino background have been found. The thermal velocities of neutrinos shifted into the non-relativistic region namely at the epoch when the cosmic photon background decoupled at about 350 000 K and due to redshift which accompanies the expansion of the Universe the radiation has turned into the 2.7 K cosmic microwave background of photons.

Whereas the redshift of particles momentum is due to expansion of the Universe, therefore it determines uniquely the cooling processes of different particles. The non-relativistic neutrino background therefore cooled further squared compared to the relativistic cosmic background of photons. In the result, at the present epoch neutrino background has temperature almost 10 000 times lower than the 2.7 K temperature of the cosmic photon background. The neutrinos have non-relativistic velocities of the order of 100 km/s and when these are crossing the galaxies they generate there the observed extensive iso-potential (constant orbital velocity) wells.

It deserves to be mentioned that also the nuclear particles cooled in the similar way to the epoch of reheating and at the beginning of this era their mean velocities probably were only about 200 m/s. This favours extreme gravitational clustering, say, starting the formation of early stars and galaxies.

The real Big Bang according to the formulae happens exactly at momentum zero and at the Planck unit time the characteristic dimension of the Universe reached to about 10^{-3} cm that exceeds the Planck unit length about 10^{30} times. This removes necessity to introduce at somewhat later epoch the inflationary expansion of the Universe due to universal repulsive forces due to hypothetic particles named inflatons. Namely, the inflation can be in traditional cosmology of the last three decades considered as real Big Bang, where practically all the matter has been created due to quantum processes from hypothetical excited false vacuum states.

The evolutionary scenario of the main physical characteristics of the Universe according to the proposed alternative concept without hypothetical inflationary expansion of the Universe, with kinetic energy of expanding Universe instead of the dark energy and neutrinos in the role of dark matter is depicted in Fig. 4.5.

The nature of the preferred non-rotating and the Coriolis force free coordinate frame in cosmology has always been a puzzle and a source of mutual misunderstanding. Taking into account that the frame is connected with the extremely remote light sources, say, the quasars and supernovae, it has been proposed that the equations of general relativity could need modification from the local complicated non-linear second order differential equations into the non-local integro-differential equations, connecting the local spacetime via the light cone to the remote regions of the Universe. A possibility to modify the equations of cosmology into the non-local ones by gravitational potential of the Universe has been shortly discussed.

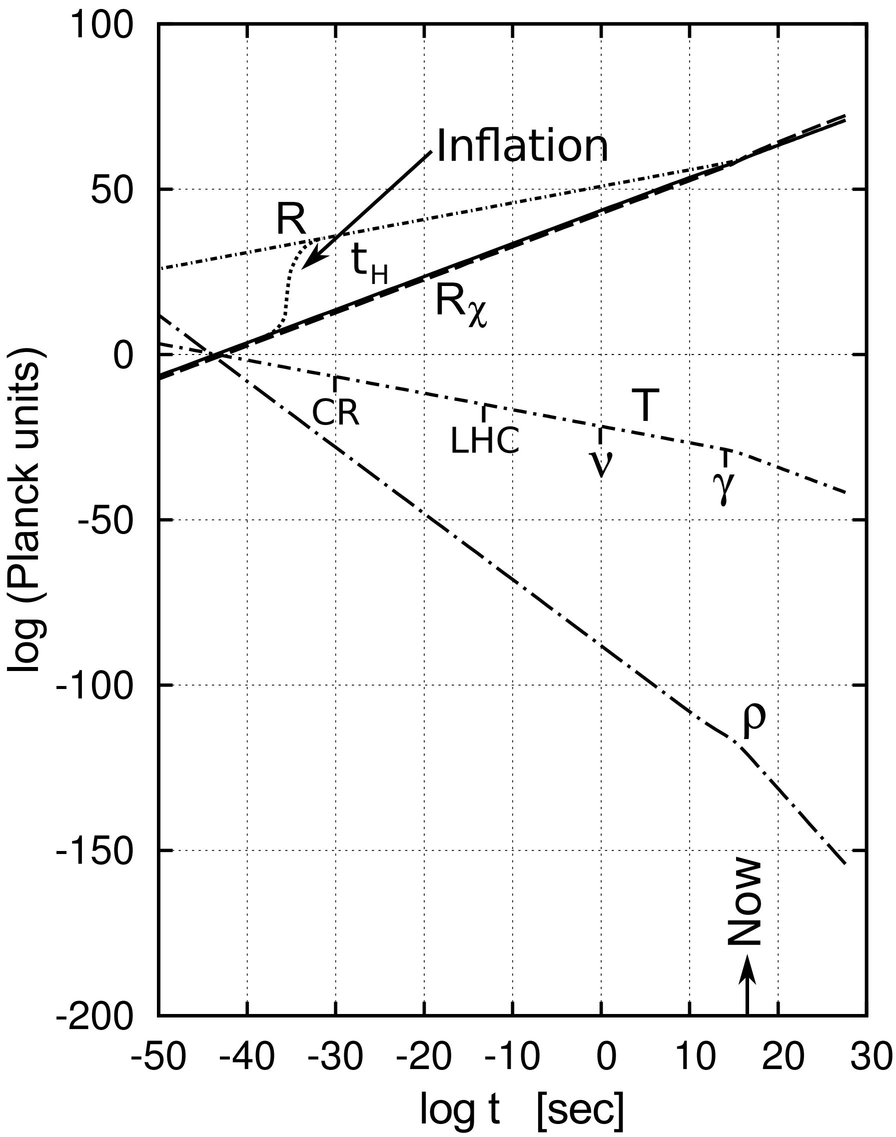


Figure 4.5: Evolution of the proposed hyperbolic Big-Bang Universe. R – radial coordinate, t_H – Hubble age, R_χ – particle horizon, T – temperature, CR – maximal energy cosmic rays, LHC – Large Hadron Collider, ν – neutrino decoupling, γ – photon decoupling, ρ – density. Inflatsiooni, tumeenergia ja tumeaine vaba alternatiivse hüperboolse Suure Paugu Universumi evolutsiooni pilt.

5 Earth Observations and Space Technology Kaugseire ja kosmosetehnoloogia

Kaugseire alased uuringud on jätkuvalt üheks oluliseks Tartu Observatooriumi teadus ja arendutegevuse suunaks. Need hõlmavad nii taimkatet, veekogusid kui ka atmosfääri. Pikaajaline uurimustöö ultraviolettkiirguse (UV) ja maapinnani jõudva päikesekiirguse vallas on kokku võetud ulatuslikes kogumikes: U. Veismanni ja K. Eerme monograafia "Päikese ultraviolettkiirgus ja atmosfääriosoon" ning K. Eerme peatükk "Päikesekiirguse aastatevaheline ja aastasisene muutlikkus" raamatule "Solar Radiation" (InTech). Metsade peegeldusomaduste sesoonsete muutuste peatükk ilmus sama kirjastuse raamatus "Forestry, Book 1" (T. Nilson, J. Pisek ja U. Peterson koos M. Rautiaineniga Helsingi Ülikoolist) ning Järvselja andmebaasi kirjeldab peatükk (A. Kuusk, M. Lang ja J. Kuusk) Springeri kirjastuse kogumikus "Light Scattering Reviews 7".

Jätkusid regulaarsed UV-kiirguse mõõtmised Benthami topeltmonokromaatoriga 290–400 nm spektripiirkonnas eesmärgiga hinnata kuu ja sesooni UV-doose ja nende mõju taimkattele ning tehismaterjalidele. Atmosfääri vastukiirguse ja seda mõjutavate tegurite uurimisel Läänemere piirkonnale iseloomuliku suhteliselt niiske ja pilvise ilma tingimustes selgus, et aasta jooksul saab maapind atmosfääri pikalainelist kiirgust ligikaudu kolm korda rohkem kui päikesekiirgust (V. Russak). Eestis kujundab vastukiirguse väärtusi kõige rohkem õhu veeauru sisaldus. Järeldoktor E. Jakobsoni ja tema doktorandi H. Keerniku atmosfääri sondeerimise alased tööd nii Eestis kui ka Arktikas pakuvad uusi võimalusi atmosfääri veeauru hulga hindamiseks. Koostöö rahvusvaheliste võrgustikega NordAquaRems ja WaterS on andunud veekaugseirajatele võimaluse osalemiseks ühisekspeditsioonidel koos teadlastega Soomest, Rootsist, Itaaliast ja Šveitsist. Tehti kasutatavate spektroradiomeetrite võrdlusmõõtmisi ja viidi läbi ka mitmepäevased mõõteseeriad ESA MERIS/Envisat sensori valideerimiseks analoogselt varasemate aastatega. Regulaarsed välitööd Peipsi järvel toimusid koostöös Eesti Hüdrometeoroloogia Instituudiga (täname O. Okulovi abi eest). Ühiselt testiti uut seadet WISP Hollandi firmalt Water Insight.

Rahvusvahelise kliimamuutuste uurimise projekti INCREASE mõõtmistel Taanis ja Itaalias osales J. Kuusk. Mõõtmisi tehti sademete ja temperatuuri gradiendil Euroopas ning katsealadel temperatuuri ja niiskuse muutusi esile kutsudes. Kasutusel olid nii SpectraVista välispektromeeter HR-1024 kui ka Tartu Observatooriumis väljatöötatud UAVSpec3 ja UAVSpec4SWIR. Metsade peegeldusomaduste atmosfäärialuseid võrdlusmõõtmisi helikopterilt tehti ka ESA eksperimetaalsatelliitile CHRIS/Proba.

Koostöös Hiina uurimisrühmaga kasutati A. Kuuse poolt välja töötatud metsade kiirguslevi mudelit FRT NASA satelliidi EO-1 spektromeetri Hyperion andmete abil metsade puuderinde ja alustaimestiku lehepinnaindeksi määramiseks Hiina Longmenhe reservaadi kolmekümnel puistul. Metsade lehepinnaindeksi määramiseks satelliitidelt analüüsisiti MODIS-e ja MERIS-e produktide adekvaatsust Eesti oludes. Selgus, et MODIS andmete alusel oli lehepinnaindeks oluliselt alla hinnatud. Aegridades ilmnesid suured juhuslikku laadi kõikumised väärtustes, mille põhjuseks tuleb pidada pilditöötlusalgoritmide suutmatust kõrvaldada madala ruumilise lahutusega (piksli suurus üle 300 m) satelliidiülesvõtetelt usaldusväärselt pilvede mõju. MODIS-e globaalse taimkatte primaarproduktsiooni (NPP) hinnang on oluliselt mõjutatud algoritmi sisendis olevatest meteo- ja pilvisuse andmetest. Tulemusena on Eesti MODIS-e NPP kaardil ida-läänesuunaline kasvav trend, mis on täpselt vastupidine metsade maapealsetest takseerandmetest saadud tüvemassi juurdekasvu hinnangule. Tuletatud on MODIS-e NPP ja CASA primaarproduktsiooni mudelite eeskujul põhialused Eesti metsade aastase primaarproduktsiooni hindamiseks 1 km^2 võrgustikul.

Boreaalsete metsade kiirgusrežiimi uuringuid viis järeldoktor J. Pisek läbi koos kolleegidega Helsingi Ülikoolist (M. Rautiainen, M. Mõttus, J. Heiskanen), Toronto Ülikoolist (L. He ja J.M. Chen) ning Bostoni Ülikoolist (C. Scaaf ja A. Strahler). Hinnati alustaimestiku peegeldusomaduste ajalist ja ruumilist muutlikkust, fütoelementide grupeerumist puuderindes ja võimalusi selle hindamiseks satelliidimõõtmistest, puulehtede kaldenurkade jaotust ja selle muutusi vegetatsiooniperioodi kestel.

Koostöös Eesti Maaülikooliga (M. Lang, T. Lükk, A. Kardakov) ja Metsabürooga (J. Anniste) katsetati võimalusi riikliku metsaressursi arvestuse registri andmete kaasajastamiseks satelliitseire andmete abil. Lageraiesarnaste häiringute pindala võrdlemisel riikliku statistikaga selgus, et metsateatised, mis näitavad omaniku soovi asuda metsas raiet tegema, ei ole usaldusväärne algmaterjal statistilise ülevaate saamiseks. Satelliidipiltidelt selgus, et alates 2005. aastast on reaalselt tehtud vaid umbes pool teatatud uuendusraietest. Euroopa elurikkuse seireprojekti (EBONE) raames testiti põllumajandusmaastikel olevate elupaigatüüpide kaardistamise võimalusi rutiinselt väikestelt (1 km^2) seirealadelt kogutavate välimõõtmisandmete ja Landsat-7 ETM+ piltide abil.

Kosmosetehnoloogia valdkonnas toimus töö Tartu Observatooriumis peamiselt kahe suurema projektiga. Esimene neist, EstSpacE jõudis edukalt veebruaris lõpule, kuid algas uus kosmosetehnoloogiaga seotud rahvusvaheline projekt ESAIL – Electric Solar Wind Sail. Selle põhiülesandeks on prototüübi tasemel välja töötada ja katsetada elektrilist päikesepurje. Meie teadlaste ülesandeks on päikesepurje nanojuhtmete otsas asuvate moodulite elektritoitesüsteemi väljatöötamine, nanojuhtme eraldamiseks mooduli küljest vajaliku päästiksüsteemi konstrueerimine ja päikesepurje testimiseks vajaliku kosmosemissiooni planeerimine. Toetatkse aktiivselt tudengite juhendamise kaudu ka Eesti tudengisatelliidi EstCube-1 projekti, mille missiooniks on testida elektrilise päikesepurje komponenti kosmoses.

5.1 Earth atmosphere and climate

In 2011 summarizing work based on the results of previous years were finished. A monograph "Solar ultraviolet radiation and atmospheric ozone" by U. Veismann and K. Eerme was published in Estonian and a chapter "Interannual and intraseasonal variations of the available solar radiation" by K. Eerme was prepared for publishing in the book "Solar radiation" of the Croatian Publishing Company InTech. Also Estonian report for the WMO/UNEP 8th Ozone Research Managers Meeting was prepared. Regular recording of UV spectra in the wavelength range 290–400 nm using Bentham double monochromator DMc150F-U based spectrometric system were continued. The major efforts are directed toward calculation of all-weather monthly and seasonal spectral dose densities and finding their variability for further studies of effects on natural plants, agricultural crops and materials. The effects of clouds and aerosol on spectral composition are studied in details.

Atmospheric counterradiation and factors forming it in the relatively moist and cloudy weather conditions in the Baltic Sea region were studied by V. Russak. The share of counterradiation in the incident radiation on ground surface varies during the year and makes on an average from 60% in summer up to 97% in winter. The annual totals of incident long-wave radiation exceed these of solar radiation about three times. In Estonia the counterradiation is mainly depending on atmospheric water vapour conditions. In average 10% of the counterradiation variations can be described by the variability of this kind of factors as: other greenhouse gases, mean and high cloudiness, temperature of ground surface, some kind of atmospheric aerosol, vertical gradients of temperature and humidity.

E. Jacobson has finished the analysis of atmospheric sounding data obtained during short-term campaign in august 2010 and solved arising measurement uncertainty related problems. He participated in the Arctic expedition making radiosonde measurements for validation of the atmospheric model at lower levels. The analysis is continuing but significant biases between widely used model and real vertical profiles were found. Ph.D. student H. Keernik has compared the results of different methods for retrieval the atmospheric precipitable water content and found promising agreement between results obtained different techniques.

A collaboration with the NASA AERONET network continues for the next ten years. A Sun photometer Cimel-318 has been measuring direct Sun radiation and sky radiance in several spectral bands for the estimation of atmosphere transparency and aerosol optical properties since 2002.

Figure 5.1: Marin Ligi started Ph.D. training in Tartu Universiti in 2011. On the picture he is using WISP for reflectance measurements. Martin Ligi alustas doktorantuuri Tartu Ülikoolis, teemaks lähikaugseire metoodika. Pildil on ta veeproove tegemas.

5.2 Remote sensing of water bodies

International networks WaterS and NordAquaRems have provided extended competences and collaboration also with Swedish, German, Finnish, Italian and Switzerland remote sensing teams. The largest international field campaign took place at Lake Vänern in Sweden. For intercalibration of the instrumentation as well as validation of ESA MERIS/Envisat products.

I. Ansko and M. Ligi performed several measurements with EMHI on Lake Peipsi (Special thanks to O. Okulov) for testing new instrument WISP (Water Insight, The Netherland). This type of close-range remote sensing methods may be very useful for small water bodies as well as under varying cloudiness, when satellites do not see the ground. However up to now this methodology needs improvement as seen from Figure 5.1, the results of new instrumentation does not coincidence well with earlier one.

Algorithm for diffuse attenuation coefficient K_d(490) for case-2 waters was elaborated by K. Alikas in collaboration with S. Kratzer from Stockholm University. Two different approaches were applied: (1) K_d as a function of inherent optical properties absorption, scattering and backscattering coefficients that are estimated from MERIS level 2 images; (2) empirical band ratio algorithm. As a result, best fit for $K_{-}d$(490) was derived while using band ratios 490/710. Validation was done over two coastal regions in the Baltic Sea (Pärnu Bay, Himmerfjärden). The results show that band ratio algorithm with 490/710 estimated $K_{-}d$(490) over wide range $0.3 - 2.3m^{-1}$ very well ($R^2 = 0.98, N = 21$).

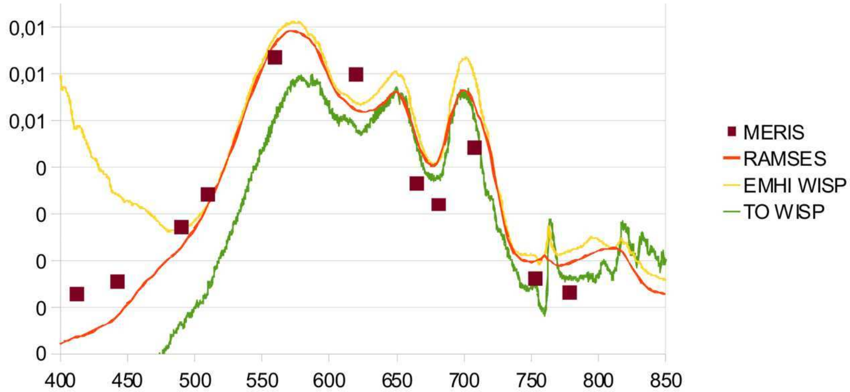


Figure 5.2: Remote sensing reflectance at Lake Peipsi measured with different devices and analyzing water samples. Peipsi järvel erinevate seadmetega mõõdetud peegeldustegurid.

5.3 Remote sensing of vegetation

Review on the long-time study about seasonal course of forest reflectance was published as a chapter in open access book ”Forestry, Book 1” (InTech Publisher) by T. Nilson, J. Pisek and U. Peterson together with M. Rautiainen (University of Helsinki) and database of optical and structural data for the validation of forest radiative transfer models (A. Kuusk, M. Lang and J. Kuusk) as a chapter for the Springer Series Book ”Light Scattering Reviews 7”.

Extensive field together with researchers from the Plant Physiology Workgroup of the Estonian University of Life Sciences took place in EU-funded infrastructure INCREASE (in Denmark and Italy) designed to study climate change effects on shrublands. The experiments combine two different approaches to study climate effects on ecosystems along a precipitation and temperature gradient in Europe and by ecosystem manipulations. UAVSpec-series spectrometers developed in Tartu Observatory (J. Kuusk) were used as stationary reference spectrometers to support the reflectance measurements with incident spectral flux data. New set of spectrometers UAVSpec3 and

UAVSpec4SWIR were also used on the helicopter measurements simultaneously to ESA experimental satellite CHRIS/Proba measurements (M. Lang, J. Kuusk, and V. Toll) on July 27th over Järvselja test site.

Together with a Chinese team from China Agricultural University, Institute of Remote Sensing Applications, National Satellite Meteorological Centre, Key Laboratory of Resources Remote Sensing and Digital Agriculture, and Joint Laboratory for Geoinformation Science (Hong Kong) A. Kuusk applied his the forest reflectance model FRT for the estimation of leaf area index (LAI) of overstorey and understorey in the Longmenhe forest nature reserve in China. Data from detailed sample sites were collected in 30 forest stands representing the typical vegetation community in the study area. To predict LAI in forest stands, FRT model inversion was performed in conjuction with EO-1/Hyperion data. The best estimates from 17 Hyperion bands (5 VIS, 8 NIR, 4 SWIR) by the FRT model inversion showed an $R^2 = 0.41$ and RMSE/mean=0.21 for overstorey LAI and $R^2 = 0.49$ and RMSE/mean=0.91 for understorey LAI.

Leaf area index (LAI) map was produced (A. Kodar, T. Nilson, M. Lang, T. Arumäe, A. Eenmäe, J. Pisek) by SPOT-4 HRV-IR and airborne lidar ALS50-II data based on canopy transmittance measurements over Järvselja VALERI (VAlidation of Land European Remote sensing Instruments) test site. This map was compared to the global LAI products from Terra MODIS and Envisat MERIS scanner systems. It appeared that MODIS LAI over the test site is significantly underestimated.

Global maps of vegetation net primary production (NPP) based on Terra MODIS measurements over Estonia were analyzed (T. Nilson, A. Eenmäe, M. Lang) and compared to the MODIS NPP with production estimates derived from forestry database. It appeared that the estimates in the MODIS NPP map over Estonia are dependent on meteorological data used in algorithm input and as a result there exists significant East-West directional increasing trend in MODIS NPP estimates. Second important factor - absorbed photosynthetically active radiation in vegetation has rather similar trend caused by decreasing of cloud cover from East to West. As a result the NPP trend in the MODIS product is exactly the opposite to the estimates based on forestry database records. Based on the ideas from the MODIS net primary production (NPP) and CASA NPP models, T. Nilson suggested a principal model scheme to estimate yearly NPP of Estonian forests on a 1 km^2 grid.

In collaboration with Helsinki University (M. Rautiainen, M. Mõttus, J. Heiskanen) J. Pisek looked at the spatial and temporal patterns of the forest background reflectance which are critically important for retrieving the biophysical parameters of the forest canopy (overstory) and for ecosystem modeling. They successfully retrieved the reflectance and seasonal changes of the forest background at 500 m resolution with the 8-day MODIS bidirec-

Figure 5.3: Helicopter measurements at Järvselja for the support of the CHRIS/Proba acquisition on 27th July 2011. Spectrometers UAVSpec3 and UAVSpec4SWNIR are fixed to the frame of Robinson 22. Metsade heledusspektrite mõõtmine kopterilt Robinson 22 spektromeetritega UAVSpec3 ja UAVSpec4SWNIR samaaegsel CHRIS/Proba mõõtmistega orbiidilt 27. juulil 2011.

tional reflectance distribution function (BRDF) model parameters product. For the first time, the satellite data derived results were directly validated with *in situ* measured seasonal reflectance trajectories of boreal forest understory layers. With teams from University of Toronto (L. He and J.M. Chen) and Boston University (C. Schaaf and A. Strahler) a first global clumping index map at 500 m resolution derived using the MODIS BRDF product was produced. The increase of foliage clumping with the height from the forest floor was documented. As a new technological solution J. Pisek carried out field measurements of foliage clumping in Järvselja, Bergius Botanic Garden (Stockholm University) and Hyytiälä field site (Finland) using leveled digital camera approach for measuring leaf inclination angles and tracking the possible seasonal variation in leaf angle distribution for alder and willow trees.

Application of modern remote sensing techniques to update state wide forest resource databases was done (T. Lükk, M. Lang, A. Kardakov) together with Metsabüroo OÜ (J. Anniste). On Landsat-7 ETM+ image from June 2010, recent forest inventory records (8921) and k nearest neighbour technique was tested to produce species composition and standing wood volume maps over Viljandimaa county. Regeneration felling like disturbances were mapped from multi-temporal images for period 2005–2010. It revealed that forest regeneration felling area from official statistics was only about half of that estimates from the map. This result was in agreement with other recent studies and indicated that forest management notices submitted to the state by forest managers or owners about their plans to start felling operations are not reliable source of information for official statistics. Also testes for mapping general habitat categories on the agricultural landscapes for European Biodiversity Observation Network (EBONE) were done (together with

A. Vain and J. Raet from Estonian University of Life Sciences).

5.4 Space technology

In the space technology field, most of the work was done on two large European Union FP7 framework programme projects. First of them, called EstSpacE, was successfully completed in the beginning of the year, but already few months before that began a new international space technology project called ESAIL – Electric Solar Wind Sail. The main task of ESAIL project is to develop and test the electric solar wind sail test mission space technology components on the prototype level. The objective of our scientists is to develop electrical power system for Remote Units that are located at the tips of the electric sail tethers, construct an ejection mechanism to detach a single tether from the electric sail module and to design a detailed plan for the space mission testing the electric solar wind sail technology. In the framework of ESAIL project Tartu Observatory organized one of the project work meetings in February this year.

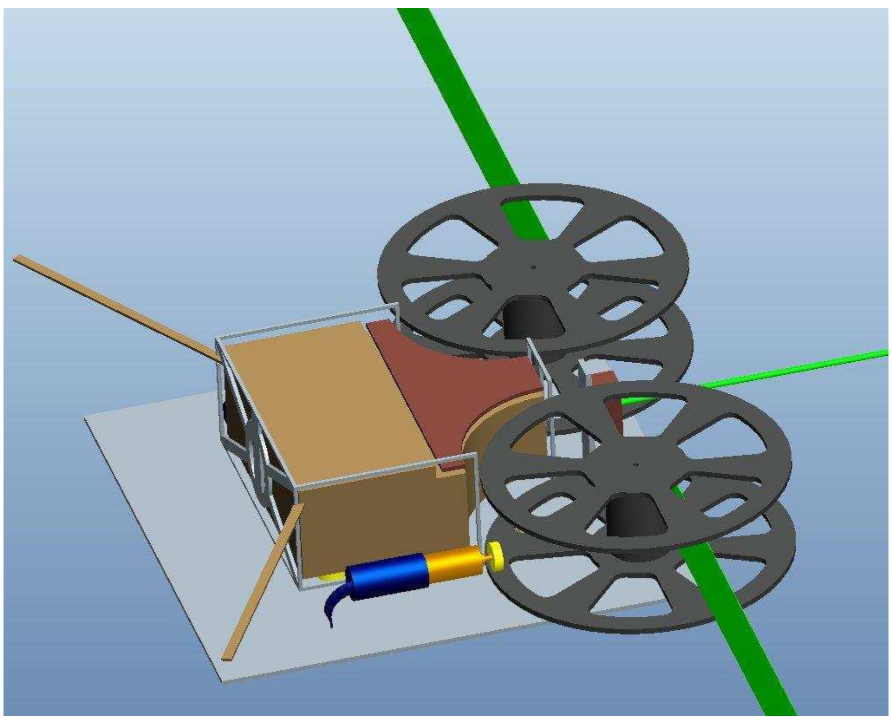


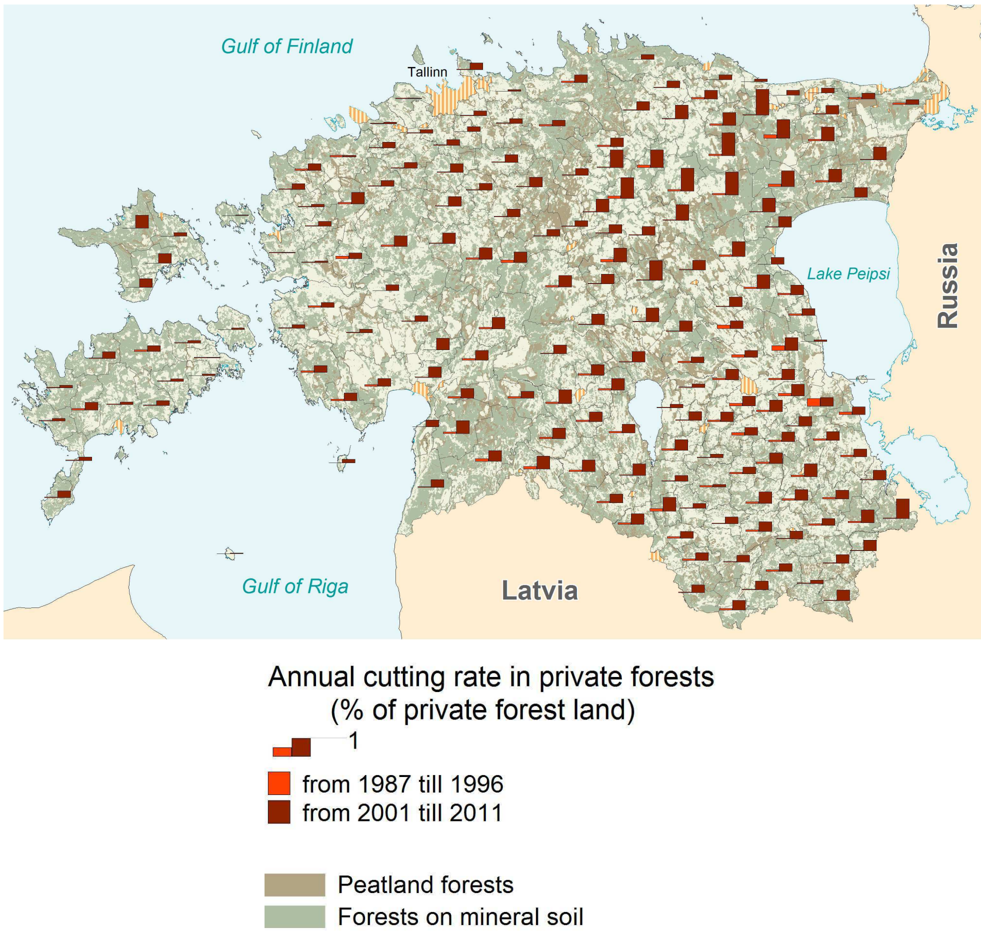
Figure 5.4: A schematic of one of the Remote Units that will be located at the tips of the electric sail tethers. Joonis ühest identsetest päikesepurje nanojuhtmete otsa tulevatest moodulitest.

One of our young scientists, U. Kvell, was assigned to the European Space Agency Technology Center ESTEC in the Netherlands, where he was part of the Electric Propulsion working group. His main task was to perform mission analysis for potential future missions of the electric sail. A new interagency working group outgrew from this activity in the European Space Agency. In cooperation we prepared the next European Union FP7 framework programme project application called SWEST for the electric solar wind sail test mission. The objective of this project is to develop and build a 70 kg satellite, which will measure actual force exerted on the electric solar wind sail. The satellite is launched to an elliptical orbit with apogee outside of Earth's magnetosphere. Once the SWEST project starts, our assignments would be to develop and build the satellite telecommunication system, part of the onboard computer, tether imager and to develop methodology for measuring the exerted force on the electric sail.

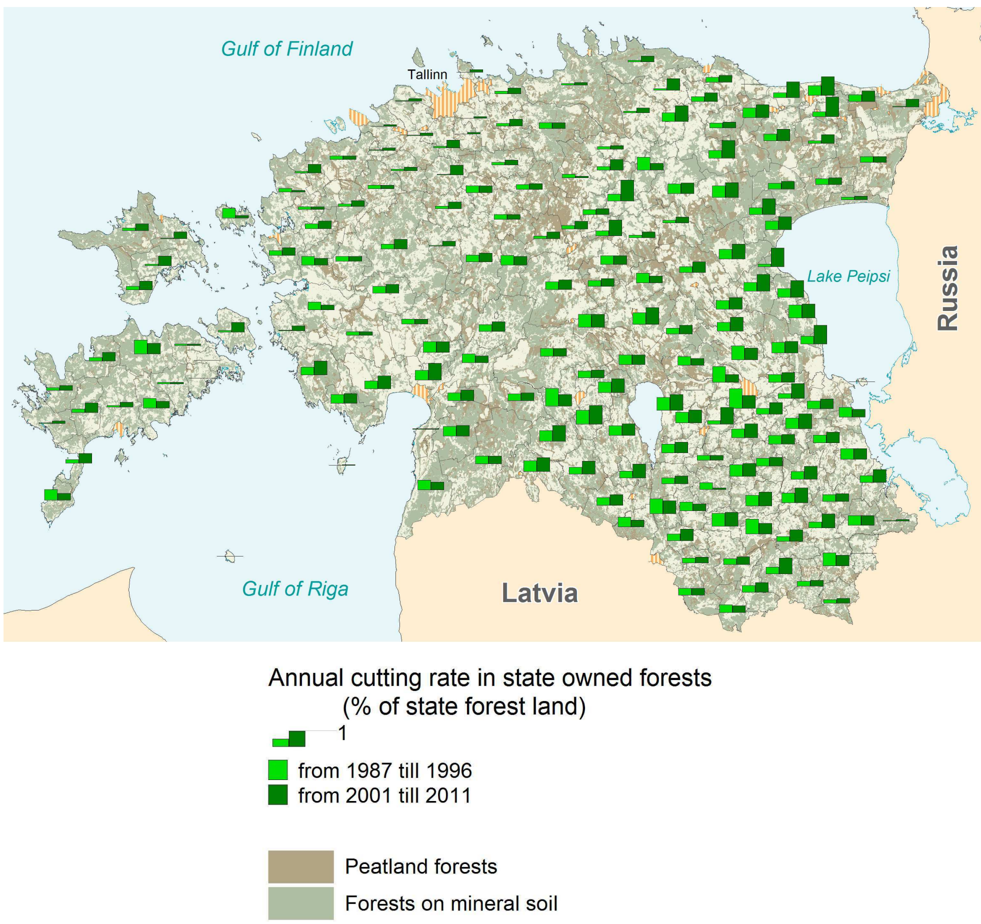
Tartu Observatory scientists have actively participated in instructing of the first Estonian student satellite EstCube-1 project. In addition to daily participation in the project teamŠs effort, two larger work meetings have been organized in the framework of EFS Exact Sciences Summer School in Nelijärve and Autumn School in Voore with the participation of international partners of EstCube.

Also the preparations for the Tartu Observatory space technology laboratory equipment acquisition have begun.

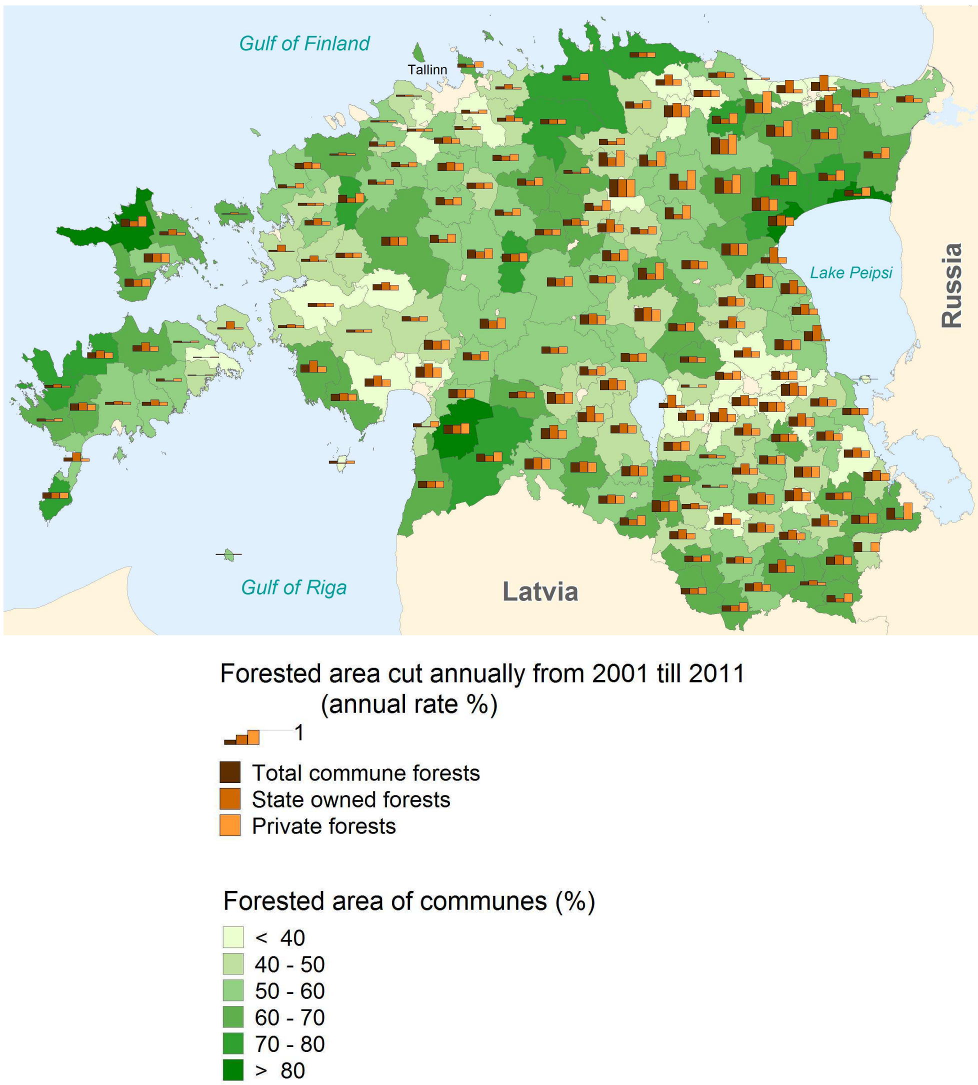
ESAIL project team in February 2011 in front of Tartu Observatory. ESAIL projekti meeskond 2011. aasta veebruaris Tartu Observatooriumi ees.



Erametsade raie aastatel 1987–1996 ja 2001–2011.



Riigimetsade raie aastatel 1987–1996 ja 2001–2011.



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TEA entsüklopeedia artiklid atmosfääriteaduste ja meteoroloogia alal – K. Eerme, V. Russak ning kosmose valdkonnas – U. Veismann

6.5 Other papers Muud artiklid

Héral S.: Vana Schmidti kool Viljandis ja noored Knorred. *Akadeemia 8*, 1507–1523, 2011. (Inglise keelest tõlkinud *T. Viik*).

Viik T.: Prangli ja Aksi. *Viimsi Teataja 1*, 14.01.2011.
Viik T.: Naissaar. *Viimsi Teataja 2*, 28.01.2011.
Viik T.: Jääalune püük. *Kostiranna küla raamat*, 78–79, Tallinn, 2011.
Viik T.: La vie mouvementée de P.L. Moreau de Maupertuis. *L'Astronomie 44*, 32–37, 2011 (inglise keelest prantsuse keelde tõlkinud S. Héral).

6.6 Preprints Preprindid

Cikała M., Mikołajewski M., Osiwała J., Tomov T., *Leedjärv L., Burmeister M.*: The Hot and the Cool Outbursts in the Symbiotic System AG Draconis. [arXiv: 1102.5210].
Hawken A. J., Abdalla F. B., *Hütsi G.*, Lahav O.: Calibrating the BAO Scale Using the CMB: Lifting the Degeneracy Between Geometric and Dynamic Distortions Using the Sound Horizon from the CMB. [arXiv:1111.2544].
Tempel E., Tago E., Liivamägi L.J.: Groups and Clusters of Galaxies in the SDSS DR8. Value-added Catalogues. [arXiv:1112.4648v1].

7 Meetings Konverentsid ja seminarid

7.1 Astronomy Astronoomia

Concluding Seminar of the FP7 Project EstSpacE (2008–2011) "Modern Trends in Space Research" (Tartu, Estonia, 09.02.2011) – A. Reinart, K. Alikas, V. Allik, I. Ansko, M. Einasto, I. Kolka, A. Kuusk, J. Kuusk, U. Kvell, L. Leedjärv, T. Liimets, T. Lillemaa, T. Nilson, M. Noorma, U. Peterson, A. Puss, M. Ruusalepp, E. Saar, A. Sapar, L. Sapar, T. Sepp, A. Tamm, T. Tuvikene, U. Veismann, J. Vennik, T. Viik.

Liimets T.: Possibilities for Young Space Researchers Through International Networking (oral presentation).

Reinart A.: An Extended Introduction (oral presentation).

Saar E.: Space for the Universe (oral presentation).

Kvell U.: Estonian Contribution to the Development of Innovative Space Missions (oral presentation).

Astronomical Seminar (Faculty of Natural Science, Masaryk University, Brno, Czech Republic, 28.02.2011) – A. Aret.

Aret A.: Diffusive Separation of Chemical Elements and Their Isotopes in Stellar Atmospheres (oral presentation).

The Prompt Activity of Gamma-ray Bursts (Raleigh, USA, 05.03.–07.03.2011) – I. Vurm .

Vurm I.: Gamma-Ray Bursts from Magnetized Collisionally-Heated Jets (oral presentation).

EuroVO-ICE School (Strasbourg, France, 19.03.–25.03.2011) – T. Sepp.

Information Meeting on LOFAR Telescope (Riga, Latvia, 18.04.2011) – L. Leedjärv.

Expanding the Universe (Tartu, Estonia, 27.04.–29.04.2011) – K. Annuk, T. Eenmäe, K. Eerme, J. Einasto, M. Einasto, M. Gramann, U. Haud, R. Kipper, T. Kipper, I. Kolka, T. Kuutma, L. Leedjärv, T. Nugis, J. Pelt, A. Puss, A. Reinart, E. Ruusalepp, M. Ruusalepp, E. Saar, A. Sapar, L. Sapar, T. Sepp, E. Tago, A. Tamm, E. Tempel, P. Tenjes, T. Tuvikene, J. Vennik, T. Viik.

Einasto J.: Dark Matter (oral presentation).

Pelt J.: Large Scale Triangulation: from Struve to Refsdal (oral presentation).

Sapar A.: Cosmological Neutrino Background and Connected Problems (oral presentation).

Tempel E.: Tracing Galaxy Evolution by their Present-Day Luminosity Function (oral presentation).

Viik T., Randjärv J.: How Struve and Tenner Started the Work of Their Life (oral presentation).

Nugis T., Annuk K.: Extinction of Radiation in the Universe from F.G.W. Struve up to Now (poster).

Sepp T.: Differences and Similarities of Galaxy Groups in the Millennium Simulation and in the SDSS DR7 (poster).

Planck WG5 Meeting (Orsay, France, 04.05.–07.05.2011) – E. Saar.

Board of Directors Meeting, "Astronomy and Astrophysics" (Porto, Portugal, 06.05.2011) – L. Leedjärv.

Planck Mission Meeting (Tuorla, Finland, 11.05.–14.05.2011) – T. Sepp.

Summer School (Tuorla, Finland, 11.05.–14.05.2011) – T. Sepp.

Understanding Relativistic Jets (Cracow, Poland, 23.05.–26.05.2011) – I. Vurm.

Vurm I.: Gamma-Ray Bursts from Magnetized Collisionally-Heated Jets (poster).

General Astronomical Seminar (Astronomical Institute of the Academy of Sciences of the Czech Republic, Ondřejov, Czech Republic, 06.06.2011) – A. Aret.

Aret A., Sapar A., Poolamäe R., Sapar L.: A Pan-Spectral Method of Abundance Determination (oral presentation).

IAU Symposium 281 "Binary Paths to Type Ia Supernovae Explosions" (Padova, Italy, 04.07.–08.07.2011) – L. Leedjärv.

Asiago Meeting on Symbiotic Stars (Asiago, Italy, 10.07.–11.07.2011) – L. Leedjärv.

Leedjärv L.: News from AG Draconis (oral report).

Conference "Cosmic Web Morphology and Topology" (Varsaw, Poland, 11.07.–18.07.2011) – J. Einasto, M. Einasto, L.J. Liivamägi, E. Saar.

Einasto J.: The Formation of the Cosmic Web With Filaments and Voids is Due to the Synchronisation of Density Waves of Medium and Large Scales and the Amplification of Both Over- and Under-Dense Regions (oral presentation).

Einasto J.: Voids are Regions in Space Where Medium- and Large-Scale Density Waves Combine (oral presentation).

Einasto J.: Owing to Phase Synchronisation, the mean Density of Matter in Void Regions is Below the Mean Density, thus Initial Small-Scale Perturbations Cannot Grow (oral presentation).

Saar E.: Large-Scale Density Maps by Kernel Methods. An Error-Bar Story (oral presentation).

Conference "Galaxy Formation" (Durham, United Kingdom, 16.07.–23.07.2011) – T. Sepp, E. Tempel.

IAU Symposium 283 "Planetary Nebulae: An Eye to the Future" (Tenerife, Spain, 25.07.–29.07.2011) – T. Liimets.

Liimets T.: The Growth of the Outflows from Evolved Stars (a live poster).

Summer School (Häädemeeste, Estonia, 08.08.2011) – J. Einasto.

Einasto J.: Structure of the Universe (oral presentation).

Gesellschaft für Kultur, Ingenieurwesen und Wissenschaft e.V., Wissenschaftliche Seminare (Dresden, Germany, 25.08.2011) – V. Malyuto.

Malyuto V.: Stellar Catalogues (oral presentation).

EUPEN's 13th General Forum "Preparing Good Physics Teachers" (Limassol, Cyprus, 28.08.–30.08.2011) – V.-V. Pustynski.

IAU Symposium 284 "The Spectral Energy Distribution of Galaxies (SED 2011)" (Preston, United Kingdom, 05.09.–09.09.2011) – A. Tamm.

IRAP PhD Erasmus Mundus School (Italy, 12.09.2011) – J. Einasto.

Einasto J.: Galactic Models (oral presentation).

Einasto J.: Formation of the Cosmic Web (oral presentation).

Einasto J.: Evolution of the Cosmic Web (oral presentation).

Astronomical Seminar (University of Helsinki, Finland, 16.09.2011) – J. Pelt.

Pelt J.: Large Scale Triangulation: from Struve to Refsdal (oral presentation).

Tartu – Tuorla Annual Meeting 2011: Remote Sensing of the Universe (Tartu, Estonia, 21.09.–22.09.2011) – M. Einasto, M. Gramann, U. Haud, R. Kipper, T. Kuutma, J. Laur, L.J. Liivamägi, E. Saar, T. Sepp, E. Tago, A. Tamm, E. Tempel, P. Tenjes, J. Vennik.

Einasto M.: Tracing Luminous and Dark Matter in the Sloan Great Wall (oral presentation).

Haud U.: NHIE, HISA and Planck CC (oral presentation).

Kipper R.: Kinematics of Distant Galaxies (oral presentation).

Kuutma T.: Analysis of Galaxy Group Members Colour Index Profiles (oral presentation).

Laur J.: Remote Observing of Luminous Stars in OB Associations (oral presentation).

Liivamägi L.J.: Superclusters in Planck Mission Observations (oral presentation).

Saar E.: Mapping the Large-Scale Dark Matter Distribution (oral presentation).

Sepp T.: The New Tartu Galaxy Cluster Catalog (oral presentation).

Tempel E.: Modelling Galaxies (oral presentation).

ASTRONET Board Meeting (Rome, Italy, 27.09.–28.09.2011) – L. Leedjärv.

Planck WG5 Working Meeting (Bologna, Italy, 16.11.–19.11.2011) – E. Saar.

International Workshop on Stellar Spectral Libraries, (University of Delhi, Delhi, India, 05.12.–09.12.2011) – V. Malyuto.

7.2 Atmospheric physics Atmosfäärifüüsika

ESAIL Project Meeting (Tõravere and Tartu, Estonia, 10.02.–11.02.2011) – V. Allik, J. Envall, U. Kvell, S. Lätt, M. Noorma.

NordAquaRemS Workshop on Remote Sensing of Lakes (Oslo, Norway, 16.02.–17.02.2011) – A. Reinart, M. Ligi.

Reinart A.: Cooperation in Water Remote Sensing – WaterS (oral presentation).

MERIS Validation Team Meeting (Ispra, Italy, 08.03.–10.03.2011) – A. Reinart, I. Ansko.

Ansko I.: TRIOS-E: Measurement Method, Data Analysis and Uncertainties (oral presentation).

Reinart A.: New Calibration Facility at Tartu Observatory (oral presentation).

ESAIL Project Meeting (Bremen, Germany, 06.04.–07.04.2011) – V. Allik, J. Envall.

34th Symposium on Remote Sensing of Environment (Sydney, Australia, 10.04.–15.04.2011) – A. Reinart.

Reinart A., Brockmann C., Kratzer S., Philpson P., Peters S., Pyhälahti T.: Strategic Partnership for Improved Basin-Scale Water Quality Parameter Retrieval From Optical Signatures – WaterS (oral presentation).

WMO/UNEP 8th Ozone Research Managers Meeting (Geneva, Switzerland, 02.05.–04.05.2011) – K. Eerme.

Radiative Transfer Theory and Practice of Hydrolight Software (Askö, Sweden, 15.05.–21.05.2011) – M. Ligi, K. Uudeberg.

WaterS Project Meeting (Brockmann Consult, Germany, 16.05.–16.06.2011) – A. Reinart.

Keskkonnainvesteeringute keskuse projektide seminar (Tartu, Estonia, 20.05.2011) – M. Lang.

Lang M., Arumäe T.: Laser mõõdab metsa (oral presentation).

31st EARSeL Symposium "Remote Sensing and Geoinformation not only for Scientific Cooperation" (Prague, Czech Republic, 30.05.–02.06.2011) – A. Kuusk.

Kuusk A., Lang M., Kuusk J.: Järvselja Test Site for Forestry Remote Sensing Studies (oral presentation).

54th Symposium of the International Association for Vegetation Science (Lyon, France, 20.06.–24.06.2011) – U. Peterson.

Peterson U., Liira J.: A Retrospective Series of Satellite Images for Studying *Macrophytic* Vegetation Dynamic in the Coastal Zones of Large Lakes (oral presentation).

The International Symposium "Atmospheric Radiation and Dynamics" (ISARD-2011) (St. Petersburg-Petrodvorets, Russia, 21.06.–23.06.2011) – V. Russak.

Ohvril H., Neiman L., Okulov O., *Russak V.*, Uustare M., Kallis A., Terez E., Terez G., Gushchin G., Abakumova G., Gorbarenko E.: Updated Multi-Annual Time Series of Column Transparency, Impact of Wildfires (oral presentation).

Kaugseire suvekool (Nelijärve Puhkekeskus, Estonia, 27.06.–29.06.2011) – J. Kuusk, J. Pisek.

Pisek J.: Sissejuhatus taimkattekaugseiresse) (invited oral presentation).

Kuusk J., Pisek J.: Välimõõtmised.

EFS Exact Sciences Summer School (Nelijärve, Estonia, 29.06.–31.07.2011) – V. Allik, T. Eenmäe, S. Lätt, M. Noorma.

2011 IEEE International Geoscience and Remote Sensing Symposium (Vancouver, Canada, 24.07.–29.07.2011) – J. Pisek.

Pisek J., Rautiainen M., Mõttus M., Heiskanen J.: Mapping Forest Understory in European Hemi-Boreal Stands Using MODIS BRDF Product (oral presentation).

He L., Chen J.M., *Pisek J.*, Schaaf C., Strahler A.: Global Clumping Index Map Derived from MODIS BRDF Products (oral presentation).

Second QB50 Workshop (Brussels, Belgium, 27.07.–28.07.2011) – M. Noorma, U. Kvell.

47th AIAA/ASME/SAE/ASEE Joint Propulsion Conference & Exhibit (San Diego, USA, 31.07.–03.08.2011) – U. Kvell.

Kvell U., Di Cara D., del Amo J.G., Janhunen P.: Deorbiting Strategies: Comparison between Electrostatic Plasma Brake and Conventional Propulsion (oral presentation).

Temporal and Spatial Validation of Forest Models (Tartu, Estonia, 22.09.2011) – M. Lang, T. Nilson.

Lang M., Kodar A., Arumäe T., Eenmäe A., *Nilson T.*: Leaf Area Index Estimation over VALERI Project (VAlidation of Land European Remote sensing Instruments) Järvselja Test Site (oral presentation).

ESAIL Project Meeting (Uppsala, Sweden, 28.08.–29.08.2011) – V. Allik.

WaterS Science Meeting 2011 (Stockholm, Sweden, 28.09.–29.09.2011) – A. Reinart, K. Alikas, E. Asuküll, M. Ligi, S. Lätt.

MERIS Validation Team Meeting (Lisbon, Portugal, 18.10.2011) – A. Reinart, I. Ansko, M. Ligi, S. Lätt.

Ansko I.: Straylight Correction for TriOS RAMSES Spectroradiometers (oral presentation).

Ligi M.: Hand Held Spectrometer (WISP) for MERIS Validation (oral presentation).

3rd CoastColour User Consultation Meeting (Lisbon, Portugal, 19.10.–20.10.2011) – A. Reinart, I. Ansko, M. Ligi, S. Lätt.

INCREASE Mid-Term Review Meeting (Alghero, Italy, 24.10.–26.10.2011) – J. Kuusk.

Kuusk J.: Spectral Reflectance Measurements in a Cloudy Day "Are they Worth the Trouble?" (oral presentation).

UK-Eastern Europe Meeting for Partnership in Space (Warsaw, Poland, 25.10.–26.10.2011) – U. Kvell.

Kvell U.: Estonian Space Activities and Active Projects (oral presentation).

EFS Exact Sciences Autumn School (Voore, Estonia, 28.10.–30.10.2011) – V. Allik, S. Lätt, M. Noorma.

ESAIL Project Meeting (Uppsala, Sweden, 07.11.–08.11.2011) – V. Allik.

International Conference "Ecosystem Design for Multiple Services with an Emphasis on Eurasian Boreal Forests" (St. Petersburg, Russia, 09.11.–11.11.2011) – U. Peterson.

Peterson U., Liira J.: Cross-Border Comparison of Forest Cover Changes in Northeastern Europe Caused by Clear-Cutting and Afforestation of Abandoned Agricultural Land (oral presentation).

Space Economy in the Multipolar World (Vilnius, Lithuania, 16.11.–18.11.2011) – U. Kvell.

Kvell U.: Towards Electric Solar Wind Sail Interplanetary Mission (oral presentation).

Finnish Remote Sensing Days 2011 (Otaniemi, Finland, 24.11.–25.11.2011) – I. Ansko, J. Kuusk, T. Nilson.

Kuusk J.: Can we Trick the Tricky weather? Reflectance Measurements in Changing Illumination Conditions (oral presentation).

Seminar AS Regio's (Tartu, 29.11.2011) – T. Nilson.

Nilson T.: Taimkattega kaetud maapinna produktsiooni ja süsinikubilansi mudelitest ja kaugseire rollist (oral presentation).

AGU Fall Meeting (San Francisco, USA, 04.12.–09.12.2011) – E. Jakobson, J. Pisek.

Jakobson E.: Validation of Atmospheric Model Analyses and Forecasts Against Tethersond Data from the Central Arctic Ocean in 2007 (poster).

Pisek J.: The Height and Seasonal Variation of Foliage Clumping: Implications for the Remote Sensing Retrievals (poster).

7.3 Miscellaneous Muud koosolekud ja ettevõtmised

Meeting of the European Union Space Policy Expert Group (Brussels, Belgium, 18.01.2011) – L. Leedjärv.

European High-Level Space Policy Group Meeting (Paris, France, 24.05.2011) – L. Leedjärv.

Participation in the EUCYS 2011 (European Union Content for Young Scientists) Jury (Helsinki, Finland, 23.09.–25.09.2011) – A. Reinart.

Konverents "Rahvuskeeled teaduses ja kõrghariduses" (TLÜ, Tallinn, 29.08.–30.08.2011) – U. Veismann.

XVI International Astronomy Olympiad (Alma-Ata, Kazakhstan, 22.09.–30.09.2011) – T. Eenmäe.

European High-Level Space Policy Group Meeting (Paris, France, 11.10.2011) – L. Leedjärv.

4th Conference on EU Space Policy (Brussels, Belgium, 08.11.–09.11.2011) – I. Kolka, L. Leedjärv.

European High-Level Space Policy Group Meeting (Paris, France, 15.11.2011) – L. Leedjärv.

7.4 Meetings at Tartu Observatory Tartu Observatooriumis korraldatud konverentsid

7.4.1 International conference "Expanding the Universe", Tartu, 27–28 April 2011 Rahvusvaheline konverents "Expanding the Universe", Tartu, 27–28 April 2011

In 2011, the 200th anniversary of the opening of the old observatory in Tartu was celebrated. Preparations to this remarkable event started well in advance. The University of Tartu, benefitting from the financial support by Enterprise Estonia, arranged renovation of the observatory building. The astronomers from the present Tartu Observatory, together with enthusiastic people from the University of Tartu History Museum started to organize a scientific conference. The title of the conference "Expanding the Universe"was derived from the fact that for several times astronomers from Tartu have played an important role in updating distance scales of the Universe and in shifting cosmological paradigms. The best known examples are measurements of the parallax of Vega by Friedrich Georg Wilhelm Struve, dynamical determination of the distance to the Andromeda nebula by Ernst Julius Öpik, and discovery of the dark matter and a regular large-scale structure of the Universe by Jaan Einasto. In 2010, a Scientific Organizing Committee (SOC) for the conference was established with Tim de Zeeuw, Director General of the European Southern Observatory as Chairman and Laurits Leedjärv as Vice-Chairman. L. Leedjärv also chaired the Local Organizing Committee (LOC) consisting of Mare Ruusalepp, Tõnu Viik (Tartu Observatory), and Lea Leppik and Reet Mägi (University of Tartu History Museum).

Celebrations started on April 27, 2011 with a Ceremonial Meeting in the Assembly Hall of the University of Tartu. Among many distinguished speakers, the President of the Republic of Estonia Mr. Toomas Hendrik Ilves delivered his warmest greetings to the historical observatory and to the present-day astronomers. The ceremony continued in the open air, in the premises of the observatory, and the nice spring day ended with two open air concerts at the same

President of the Republic of Estonia Mr. Toomas Hendrik Ilves. Eesti Vabariigi President Toomas Hendrik Ilves.

place. The scientific conference "Expanding the Universe" was held on April 28 and 29 in the White Hall of the University of Tartu History Museum. It was devoted both to the history of astronomy (and geodesy) in Tartu and to the present-day research trends stemming from the ideas arisen in Tartu. The titles of the four sessions reflect this mixture of historical and modern: (1) Astronomy around the Baltic Sea – before and after Struve; (2) From 19th to 21st century: the Sun, stars, and galaxies; (3) The Universe, dark and bright; (4) New astronomy: neutrinos, magnetars, radiative transfer...

Director General of the European Southern Observatory, Tim de Zeeuw. Euroopa Lõunaobservatooriumi peadirektor Tim de Zeeuw.

About 60 people from 10 countries participated in the conference. About 20 talks were given, including longer invited reviews by Professors Victor Abalakin (former director of the Pulkovo Observatory, Russia), Christiaan Sterken (Vrije Universiteit Brussel, Belgium), Tim de Zeeuw (Director General of ESO), Erik Hog (Copenhagen University, Denmark), and our own Jaan Einasto. Five posters were also displayed. Proceedings of the conference were published in late 2011 as a special issue of the journal "Baltic Astronomy", edited by Christiaan Sterken, Laurits Leedjärv and Elmo Tempel.

Lea Leppik from the University of Tartu History Museum compiled a 216-page large format generously illustrated book "Tartu Old Observatory" with a text in parallel in Estonian and in English. Among numerous authors there are Jaan Einasto, Erik Tago and Tõnu Viik from the present-day Tartu Observatory. Tõnu Viik was also a scientific consultant for the whole book.

2011. aastal tähistati Tartu Tähetorni avamise 200. aastapäeva. Selle tähtsündmuse ettevalmistamine algas varakult. Tartu Ülikool laskis Ettevõtluse Arendamise Sihtasutuse toetuse abil vana hoone korralikult renoveerida. Praeguse Tartu Observatooriumi astronoomid koos entusiastlike kolleegidega Tartu Ülikooli ajaloo muuseumist hakkasid korraldama teaduskonverentsi. Konverentsi nimetus "Expanding the Universe"(avardades Universumit) tuletati sellest, et Tartu astronoomid on ajaloos mitmel korral olnud esimesed

Universumi kaugusskaalade paikapanekul ja kosmoloogiliste paradigmade muutmises. Tuntuimad näited on Veega parallaksi mõõtmine Friedrich Georg Wilhelm Struve poolt, Andromeeda udu kauguse dünaamiline määrang Ernst Julius Öpiku poolt ning Jaan Einasto avastatud tume aine ja Universumi kärgstruktuur. 2010. aastal moodustati konverentsi teaduslik korralduskomitee (SOC), mille esimeheks sai Euroopa Lõunaobservatooriumi peadirektor Tim de Zeeuw ja aseesimeheks Laurits Leedjärv. Viimane oli ka kohaliku korralduskomitee (LOC) esimees, sinna kuulusid veel Mare Ruusalepp ja Tõnu Viik ning Lea Leppik ja Reet Mägi TÜ ajaloo muuseumist.

Participants of the Meeting. Konverentsist osavõtjad.

Pidustused algasid 27. aprillil 2011 piduliku koosolekuga Tartu Ülikooli aulas. Teiste hulgas andis oma soojad tervitused ajaloolisele Tähetornile ja tänapäeva astronoomidele edasi Eesti Vabariigi president Toomas Hendrik Ilves. Üritused jätkusid Tähetorni juures vabas õhus ning kaunis kevadpäev jõudis õhtusse kahe vabaõhukontserdiga sealsamas. Teaduskonverents toimus 28. ja 29. aprillil TÜ ajaloo muuseumi valges saalis. Konverentsi tematikas olid esindatud nii astronoomia (ja geodeesia) ajalugu Tartus kui tänapäevased teadussuunad astronoomias, mis on lähtunud Tartus tekkinud ideedest. Sellist ajaloolise ja kaasaegse segu iseloomustavad nelja sessiooni pealkirjad: (1) Astronoomia Läänemeremaades enne ja pärast Struvet; (2) Üheksateistkümnendast sajandist kahekümne esimesse: Päike, tähed ja galaktikad; (3) Universum, tume ja hele; (4) Uus astronoomia: neutriinod, magnetarid, kiirguslevi...

Konverentsist võttis osa umbes 60 inimest 10 riigist. Esitati ligi 20 ettekannet, mille hulgas professorid Victor Abalakin (Pulkovo Observatooriumi endine direktor, Venemaa), Christiaan Sterken (Brüsseli Vaba Ülikool, Belgia), Tim de Zeeuw (ESO peadirektor), Erik Hog (Kopenhaageni Ülikool, Taani) ja meie oma Jaan Einasto esitasid pikemad tellitud ülevaate-ettekanded. Samuti oli väljas viis posterit. Konverentsi ettekanded ja posterid avaldati 2011. aasta lõpul ajakirja "Baltic Astronomy" erinumbrina, mille toimetajad olid Christiaan Sterken, Laurits Leedjärv ja Elmo Tempel.

Pidustuste ajaks ilmus ka Lea Leppiku (TÜ ajaloo muuseum) koostatud 216-leheküljeline suureformaadiline rikkalikult illustreeritud raamat "Tartu Tähetorn", mille tekst on paralleelselt nii eesti kui inglise keeles. Raamatu arvukate autorite seas on Jaan Einasto, Erik Tago ja Tõnu Viik praegusest Tartu Observatooriumist. Tõnu Viik oli ka kogu raamatu teaduslik konsultant.

7.5 Workshop "Modern Trends in Space Research 2011" Seminar "Kosmose uurimise uudsed trendid 2011"

Workshop "Modern Trends in Space Research 2011" was organized in Tartu, Estonia on February 9th 2011. There were about 100 participants from the Estonian space research community and decision makers on the workshop, where the modern trends of the space research in European Research area were presented by international high level scientists, members of EstSpacE Advisory Council. During the meeting the research priorities of Tartu Observatory for 2011–2015 were presented. The results of the EstSpacE project and the opportunities for young researchers in the European R& D community were introduced as well. After the workshop a special Advisory Council meeting took place at the Old Tartu Observatory and Jaan Einasto held a presentation about 200 years of Tartu Observatory.

The main objective of the EstSpacE project was to increase the level of international cooperation and create the necessary conditions for utilizing the existing and emerging research potential of the Estonian scientific institutes in the field of remote sensing, atmospheric physics, and astronomical research as well as provide technological support for harmonization of the radiometric and photometric measurements.

The EstSpacE project as whole increased the visibility and collaboration of the Estonian space scientists with public, industry, enterprises and policy on national and European level. It also improved awareness of the European Union space policy on the national level.

Presentations at the conference:

- Pinty B. (ESA, ESRIN/JRC, Italy): ESA's Actions and Perspectives in Land Applications.
- Doerffer R. (GKSS, Germany): Novel methods in water remote sensing.
- Staerke D. (CNES, France): Space for education.

Participants of the workshop. Seminarist osavõtjad.

- Prusti T. (ESA, ESTEC, The Netherlands): Astronomy at ESA.
- Saar E. (TO, Estonia): Space for the Universe.
- Janhunen P. (FMI, Finland): Electric Solar Wind Sail Technology.
- Mikson E. (Archimedes, Estonia): Further trends in European space research by new framework program (slide show during coffee break).
- Võõras M. (EAS, Estonia): Estonian activities in the frame of ESA Plan for European Cooperating States (PECS).
- Liimets T. (TO, Estonia): Possibilities for young space researchers through international networking.
- Kvell U. (ESA international research fellow, TO, Estonia): Estonian contribution to the development of innovative space missions.
- Einasto J. (TO, Estonia): 200 years of Tartu Observatory.
- Anu Reinart, Laurits Leedjärv, Urmas Peterson, Mart Noorma: Presentations and discussions on scientific priorities 2011–2015.

9. veebruaril 2011 toimus Tartus, vastvalminud AHHAA keskuses rahvusvaheline seminar "Kosmose uurimise uusimad trendid 2011". Seminaril osales üle 100 kosmosevaldkonnas tegutseva spetsialisti üle Eesti. EstSpacE nõuandva kogu liikmed tutvustasid kaasaegseid suundumusi kosmose uurimisega seotud valdkondades, kus ka Tartu Observatoorium aktiivselt kaasa lööb. Seminaril esitleti Tartu Observatooriumi teadus- ja arendustegevuse prioriteete aastateks 2011–2015 ning EstSpacE projekti tulemusi. Oma visiooni Tartu Observatooriumist kui perspektiivikaid tulevikuväljavaateid

pakkuvast töökohast Euroopa teadusruumis esitasid noored teadlased. Ettekannetele järgnes pidulik nõuandva kogu istung renoveeritud Tartu Tähetornis Toomemäel, kus akadeemilise ettekandega esines akad. Jaan Einasto. 10. veebruaril 2011 viisid EstSpacE nõuandva kogu liikmed läbi seminarid astronoomia, kaugseire ja kosmosetehnoloogia valdkondades.

Director of the Tartu Observatory Anu Reinart. Tartu Observatooriumi direktor Anu Reinart.

On February 10th 2011 the AC members gave seminars on their research topic in Tartu Observatory.

- *Prusti T.*: Gaia – Science with 1 billion objects in three dimensions.
- *Pinty B.*: Exploiting Surface Albedos to document Land Surface Properties.
- *Janhunen P.*: Elecrtonic Solar Sail Technology.

7.5.1 Tartu-Tuorla Annual Meeting 2011: ”Remote Sensing of the Universe”. 21–22 September, Tartu. Tartu-Tuorla ühisseminar ”Remote Sensing of the Universe”. 21–22 September, Tartu.

This year′s meeting was already seventh Tartu – Tuorla joint meeting. We had more than 30 participants from Tartu Observatory and Tartu University, Institute of Physics, Tuorla Observatory, Finnish Centre of Astronomy with ESO at Turku University and from National Institute of Chemical Physics and Biophysics with more than twenty talks and many discussions between the talks. We also had a special session of the Centre of Excellence ”Dark Matter in

(Astro)particle Physics and Cosmology", a session on Planck mission, and a traditional football game between the national teams of Estonian and Finnish astronomers. The meeting ended with a visit to AHHAA science center. The topics of the talks spanned from the nature of dark matter as seen from the astroparticle point of view: on the Higgs boson and scalar-tensor cosmology, to the nature of dark matter from studies of the large scale structure of the Universe, density fields and superclusters. Our talks covered the studies of our cosmic neighborhood: exoplanets, stars and the structure of our Galaxy, analysis of nearby and distant galaxy groups and clusters, and superclusters and their systems. Samuli Kotiranta from Tuorla Observatory spoke about the application of Bayesian methods in search for exoplanets. U. Haud talked of very cold hydrogen clouds, found by him in the Leiden-Argentina-Bonn HI survey and their relation with the HI self-absorption clouds and Planck cold clumps, studied by other teams. Tommi Vornanen from University of Turku spoke about spectropolarimetry, Jaan Laur about remote observations of stars, and Riho Reintal from Tartu (now in Tuorla Observatory) about using the Magic telescope to detect gamma-rays from blazars. E. Tempel, R. Kipper and T. Kuutma spoke about models of nearby and high-redshift galaxies, and about photometry of galaxies in nearby groups. Talks by Pasi Nurmi and M. Einasto were dedicated to Tartu and Tuorla joint studies of the structure of galaxy groups from observations and simulations, and studies of the structure and galaxy content of the richest superclusters in the Sloan Great Wall. T. Sepp spoke about the new catalogue of rich galaxy clusters, and Heidi Lietzen about our joint study of the environments of active galaxies and QSOs. E. Saar introduced methods to map of the visible and dark matter in the Universe, and L.J. Liivamägi spoke about the discovery of galaxy superclusters with the Planck mission. Talks by Pekka Heinämäki, Juha Reunanen, and Jukka Nevalainen were dedicated to the present and future space missions: Euclid and ATHENA/XMS. A special session was dedicated to the problems of astroparticle physics and scalar-tensor cosmology, with talks by Emidio Gabrielli, Laur Järv and Antonio Racioppi. Most importantly, the Tartu – Tuorla meeting was a good opportunity for our young researchers to present their results at an in-ternational meeting, and to discuss our ongoing and future collaboration in studies of galaxies, galaxy systems and of the whole Universe.

21.–22. septembril 2011 aastal peeti Tartus seitsmendat iga-aastast Tartu – Tuorla observatoomiumide ühisseminari, mille teemaks oli seekord "Universumi kaugvaatlemine". Seminarist osavõtjaid oli üle kolmekümne, lisaks Tartu Observatooriumi kosmoloogidele ja tähefüüsikutele ja Tuorla Observatooriumi astronoomidele oli osavõtjaid ka Tartu Ülikoolist, TÜ Füüsika Instituudist, Keemilise ja Bioloogilise Füüsika Instituudist Martti Raidali rühmast ja Soome ESO Astronoomiakeskusest. Kokku peeti üle kahekümne ettekande ja hulgaliselt arutelusid. Oli ka äsja loodud teaduse tippkeskusele "Universumi tumeaine astroosakeste füüsikas ja kosmoloogias" pühendatud istung ja Plancki kosmoseteleskoobi andmetöötlusele pühendatud istung. Tõraveres peeti Eesti – Soome astronoomide rahvusmeeskondade traditsiooniline jalgpallimäng, mis seekord lõppes soomlaste võiduga. Seminar lõppes planetaariumietendusega AHHAA keskuses. Ettekannete teemad käsitlesid tumeaine uurimist astroosakeste füüsika meetoditega ja kosmoloogiliste meetoditega Universumi suureskaalalise ehituse uurimise kaudu. Lisaks räägiti meie kosmilise lähi- ja kaugema ümbruse uurimisest: eksoplaneetidest, tähtede vaatlemisest, meie Galaktika ehituse uurimisest, lähemate ja kaugemate galaktikagruppide uurimisest ning superparvede ja kosmilise võrgustiku uurimisest. Samuli Kotiranta Tuorla Observatooriumist kõneles Bayesi meetodite kasutamisest eksoplaneetide otsimisel. U. Haud rääkis tema poolt Leiden-Argentina-Bonn HI vesiniku taevaülevaate andmete põhjal avastatud väga külmadest vesinikupilvedest ja nende seosest Plancki andmete põhjal avastatud külmade aineklompidega. Tommi Vornanen Turu Ülikoolist tutvustas spektropolarimeetria probleeme, Jaan Laur rääkis tähtede kaugvaatlustest, ning Riho Reintal, kes tegi oma magistritöö Tartu Observatooriumis ja õpib nüüd Tuorla Observatooriumis, rääkis Magic teleskoobist ja tööst blasaritest pärinevate gammakiirte avastamisel. E. Tempel, R. Kipper ja T. Kuutma Tartu Observatooriumist ja Tartu Ülikoolist rääkisid lähedaste ja kaugete galaktikate mudelitest ja fotomeetrilisest uurimisest. Muuhulgas tutvustas E. Tempel tööd enam kui 800 000 galaktika mudeli koostamisel Sloani Digitaalse Taevaülevaate andmete põhjal. Pasi Nurmi ja M. Einasto ettekanded olid pühendatud Tartu ja Tuorla kosmoloogide ühistele töödele galaktikagruppide ja superparvede uurimisel nii vaatlusandmete kui kosmoloogiliste simulatsioonide abil, sealhulgas suurima teadaoleva galaktikasüsteemi – Sloani Suure Seina superparvede ning nende galaktilise koostise uurimisele. T. Sepp tutvustas uut rikaste galaktikaparvede kataloogi, mille koostamine on praegu veel pooleli. Heidi Lietzen rääkis Tuorla ja Tartu kosmoloogide ühistööst aktiivsete galaktikate ümbruse uurimisel. E. Saar tutvustas meetodeid Universumi nähtava ja tumeaine kaardistamiseks tihedusväljade abil. L.J. Liivamägi rääkis galaktikate superparvede avastamisest Plancki ja teiste kosmoseteleskoopide ning Sloani Digitaalse taevaülevaate andmete põhjal. Pekka Heinämäki, Juha Reunanen ja Jukka Nevalainen tutvustasid tulevasi kosmoseteleskoope ja nendega tehtavat teadustööd Universumi ehituse, tumeaine ja tumeenergia olemuse uurimisel ja galaktikaparvede ning galaktikatevahelise aine uurimisel. Eraldi istung, millel esinesid Emidio Gabrielli, Laur Järv ja Antonio Racioppi, oli pühendatud astroosakeste füüsikale ja kosmoloogiale. Ettekannetest mitte vähem olulised olid praeguse ja tulevase ühistöö arutelud ettekannete vaheaegadel. Tartu – Tuorla ühisseminar on ka noortele astronoomidele heaks võimaluseks esinemiseks rahvusvahelisel seminaril.

8 Visits and guests Visiidid ja külalised

8.1 Astronomy Astronoomia

G. Hütsi – Max Planck Institute for Astrophysics (Garching, Germany); 14.02.–16.05.2011.

T. Liimets – Kapteyn Astronomical Institute, Groningen (The Netherlands); 28.02.–11.03.2011.

I. Vurm – Columbia University, New York (USA); 08.03.–11.03.2011.

T. Liimets – Centro de Astrofísica en La Palma, La Palma (Spain); 14.03.–05.08.2011.

U. Haud – Argelander-Institut für Astronomie, Universität Bonn (Germany); 09.06.–11.06.2011.

I. Vurm – University of Oulu, Oulu (Finland); 14.06.–22.06.2011.

A. Aret – Ondřejov Observatory (Czech Republic); 07.01.–30.06.2011, 15.07.–30.09.2011.

I. Ansko, M. Ligi – (Vänern, Sweden); 02.08.–08.08.2011.

L. Leedjärv, A. Reinart, A. Tamm – European Southern Observatory Headquarters (Garching, Germany); 17.08.–18.08.2011.

J. Einasto – ICRANet, Pescara (Italy); 04.09.–07.11.2011.

J. Pelt – University of Helsinki (Finland); 11.09.–17.09.2011.

G. Hütsi – Max Planck Institute for Astrophysics (Garching, Germany); 03.10.–04.11.2011.

L.J. Liivamägi – Tuorla Observatory, University of Turku (Finland); 24.10.–28.10.2011.

E. Tempel – Observatori Astronómic, Universitat de Valéncia, Valéncia (Spain); 24.10.– 25.11.2011.

E. Saar – Observatori Astronómic, Universitat de Valéncia, Valéncia (Spain); 24.10.– 22.12.2011.

I. Kolka, L. Leedjärv – Royal Observatory Belgium, Brussels (Belgium); 07.11.–09.11.2011.

G. Hütsi – Max Planck Institute for Astrophysics (Garching, Germany); 14.11.2011.–21.12.2011.

T. Tuvikene – Vrije Universiteit Brussel (Belgium); 11.12.–16.12.2011.

8.2 Atmospheric physics Atmosfäärifüüsika

A. Reinart – Norwegian Space Centre, Oslo (Norway); 16.02.–17.02.2011.

M. Ligi – Norwegian Space Centre, Oslo (Norway); 16.02.–17.02.2011.

A. Reinart – Frascati (Italy), 07.03.–10.03.2011.

I. Ansko – Frascati (Italy), 07.03.–10.03.2011.

J. Kuusk – Viterbo University and INCREASE Climate Change Experiment Site in Porto Conte (Italy); 18.04.–30.04.2011.

A. Reinart – Brockmann Consult GmbH, Hamburg (Germany); 16.05.–16.07.2011.

J. Kuusk – INCREASE Climate Change Experiment Sites in Mols and Brandbjerg (Denmark); 06.06.–19.06.2011, 01.08.–14.08.2011.

M. Ligi – Water Insight, Wageningen (Netherlands); 01.09.–01.02.2012.

K. Alikas – Vattenfal Power Consultant AB, Stockholm (Sweden); 26.09.2011–28.02.2012.

M. Ligi – Wageningen (Sweden); 26.09.2011–28.02.2012.

A. Reinart – Stochkolm University (Sweden); 28.09.–29.09.2011.

K. Alikas – Stochkolm University (Sweden); 28.09.–29.09.2011.

S. Lätt – Stochkolm University (Sweden); 28.09.–29.09.2011.

M. Ligi – Stochkolm University (Sweden); 28.09.–29.09.2011.

E. Asuküll – Stochkolm University (Sweden); 28.09.–29.09.2011.

E. Jakobson – Finnish Meteorological Institute (FMI), Helsinki (Finland); 11.10.–12.10.2011.

J. Pisek – Hyytiälä Forest Field Station (Finland); 17.11.2011.

I. Ansko, J. Kuusk, T. Nilson – Aalto University, Helsinki (Finland); 24.11.–25.11.2011.

A. Reinart – Visiting Centre for Research and Higher Education in Ensenada (CICESE) (Mexico); 03.12.–12.12.2011.

8.3 Guests of the observatory Observatooriumi külalised

Katarina Eriksson – Vattenfall Power Consultant AB (Sweden); 01.01.–14.01.2011.

Timo Prusti – ESA, ESTEC, Noordwijk (The Netherlands); 09.02.–10.02.2011.

Pekka Heinämäki – Tuorla Observatory, University of Turku (Finland); 01.02.–28.02.2011; 21.09.–22.09.2011.

Pasi Nurmi — Tuorla Observatory, University of Turku (Finland); 01.02.–28.02.2011.

Danielle De Staerke – Centre National d'Etudes Spatiales (CNES) (France); 08.02.–11.02.2011.

Roland Doerffer – Helmholtz Center Geesthacht, Institute of Coastal Research (Germany); 08.02.–11.02.2011.

Bernard Pinty – Joint Research Centre, Ispra (Italy); 08.02.–11.02.2011.

Pekka Janhunen – Finnish Meteorological Institute (Finland); 08.02.–11.02.2011.

Petri Toivanen – Finnish Meteorological Institute (Finland); 08.02.–11.02.2011.

Timo Prusti – European Space Agency, ESA (Netherlands); 08.02.–11.02.2011.

Bernard Pinty – ESA, ESRIN, Frascati/Joint Research Center, Ispra (Italy); 09.02.–10.02.2011.

Roland Doerffer – GKSS (Germany); 09.02.–10.02.2011.
Danielle de Staerke – CNES (France); 09.02.–10.02.2011.
Pekka Janhunen – FMI (Finland); 09.02.–10.02.2011.
Henri Seppänen – University of Helsinki (Finland); 10.02.–11.02.2011.
Tuomo Ylitalo – University of Helsinki (Finland); 10.02.–11.02.2011.
Greger Thornell – Ångström Space Technology Centre, Uppsala Univesity (Sweden); 10.02.–11.02.2011.
Johan Sundqvist – Ångström Space Technology Centre, Uppsala Univesity Sweden); 10.02.–11.02.2011.
Henrik Kratz – Ångström Space Technology Centre, Uppsala Univesity (Sweden); 10.02.–11.02.2011.
Høakan Johansson – NanoSpace AB, Uppsala Science Park, Uppsala (Sweden); 10.02.–11.02.2011.
Tor-Arne Grönland – NanoSpace AB, Uppsala Science Park, Uppsala (Sweden); 10.02.–11.02.2011.
Roland Rosta – German Aerospace Center DLR, Bremen (Germany); 10.02.–11.02.2011.
Pierpaolo Pergola – Alta, Pisa (Italy); 10.02.–11.02.2011.
Nicola Giusti – Alta, Pisa (Italy); 10.02.–11.02.2011.
Emil Vinterhav – OHB Sweden, Stockholm (Sweden); 10.02.–11.02.2011.
Henri Seppänen – University of Helsinki (Finland); 10.02.–11.02.2011.
Tuomo Ylitalo – University of Helsinki (Finland); 10.02.–11.02.2011.
Maria Haupt – University of Potsdam (Germany); 14.02.–28.02.2011.
Jasmin Geissler – Brockmann Consult GmbH (Germany); 28.02.–31.05.2011.
Martin Klimánek – Mendel University in Brno (Czech Republic); 13.05.2011.
Mauri Valtonen – Tuorla Observatory, University of Turku (Finland); 03.06.2011.
Radu Stoica – Universite Lillé (France); 01.07.–14.07.2011.
Petra Philipsson – Brockmann Geomatics Sweden AB (Sweden); 01.07.–30.09.2011
Tommi Vornanen – University of Turku (Finland); 21.09.–22.09.2011.
Samuli Kotiranta – Tuorla Observatory, University of Turku (Finland); 21.09.–22.09.2011.
Seppo Katajainen – FINCA, University of Turku (Finland); 21.09.–22.09.2011.
Heidi Lietzen – Tuorla Observatory, University of Turku (Finland); 21.09.–22.09.2011.
Jukka Nevalainen – FINCA, University of Turku (Finland); 21.09.–22.09.2011.
Juha Reunanen – Tuorla Observatory, University of Turku (Finland); 21.09.–22.09.2011.
Pasi Nurmi – Tuorla Observatory, University of Turku (Finland); 21.09.–22.09.2011.
Karlis Zalite – Ventspils International Radio Astronomy Center (Latvia); 06.10.2011.

Olaf Krüger – Brockmann Consult GmbH (Germany); 22.10.2011–21.01.2012.
Miina Rautiainen – University of Helsinki (Finland); 03.11.2011.
Michaela Kraus – Astronomical Institute of the Academy of Sciences of the Czech Republic; 28.11.–05.12.2011.

9 Seminars at the Observatory Observatooriumis toimunud seminarid

9.1 Astronomy Astronoomia

05.01.2011 – Anna Aret: Ondřejovi Observatoorium.

26.01.2011 – Antti Tamm: Muljeid mustalt mandrilt, Burkina Faso.

10.02.2011 – Timo Prusti (ESA, ESTEC, Noordwijk): Gaia: Science with One Billion Objects in Three Dimensions.

17.02.2011 – Pekka Heinämäki (Tuorla Observatory): Searching for WHIM.

17.02.2011 – Pasi Nurmi (Tuorla Observatory): Some Effects of Dark Matter in Large and Small Scales in the Universe.

09.03.2011 – Arutelu teemal "Kuidas hakkame lähenema ESO-le".

09.03.2011 – Elmo Tempel: Tracing Galaxy Evolution by Their Present-day Luminosity Functions.

16.03.2011 – Stefan Groote (Tartu Ülikooli Füüsika Instituut): Universum katseklaasis ehk mida kaootilised stringid meile reedavad.

06.04.2011 – Maria Haupt (Potsdami Ülikool): SDSS-DR8 Galaktika parvede kataloog.

01.04.2011 – Arutelu teemal "Kosmos ja meie – 50 aastat J. Gagarini lennust".

04.05.2011 – Prof. Kalle Kirsimäe (Tartu Ülikool): Vee ja elu otsingud Marsil: uued väljakutsed.

25.05.2011 – Jaan Kaplinski: Tähed ja nimed.

08.06.2011 – Anti Hirv: Estimation of Time Delays from Light Curves of Gravitationally Lensed Quasars (ülevaade doktoritööst).

15.06.2011 – Vladislav-Venjamin Pustõnski: Apollo 11 pildistiku fotogrammeetria.

14.09.2011 – Maret Einasto: Superparvede morfoloogiast.

28.09.2011 – Maret Einasto: Superparvede uurimine peakomponentide analüüsiga.

05.10.2011 – Tõnu Viik: Friedrich Wilhelm August Argelander ja Soome astronoomia.

12.10.2011 – Urmas Haud: Neutraalse vesiniku kitsajoonelise kiirgusega pilved, omaneeldumispiirkonnad ja Plancki külmad klombid.

26.10.2011 – Anna Aret: Vaatlused Ondřejovi Observatooriumi 2-m teleskoobiga.

30.11.2011 – Michaela Kraus (Tšehhi TA Astronoomia Instituut): B[e] Supergiants – Their Connection to Other Post-Main Sequence Phases of Massive Stars.

9.2 Atmospheric physics Atmosfäärifüüsika

14.01.2011 – Johann Kütt: Inglismaalt Tõraverre – Kosmosetehnoloogia õpingud Surrey Ülikoolis.

10.02.2011 – Bernard Pinty (JRC/ESA-ESRIN): Exploiting Surface Albedos to Document Land Surface Properties.

04.03.2011 – Erko Jakobson: Vertikaalse niiskusjaotuse ajaline muutlikkus sondeerimisandmete ning ilmamudelite põhjal.

04.03.2011 – Kalju Eerme: Atmosfääriuurimine Tõraveres, mis ja milleks?

08.04.2011 – Andres Kuusk, Tiit Nilson: Studies on reflectance modelling.

08.04.2011 – Mait Lang, Joel Kuusk, Amdres Kuusk: Järvselja experimental test site.

08.04.2011 – Jan Pisek: Mapping forest understory over Finland/Järvselja RAMI stands using MODIS BRDF product.

25.03.2011 – Jasmin Geissler (Brockmann Consult): Cooperative Activities in Ecological Mapping of Lakes within the project WaterS.

13.05.2011 – Martin Klimanek (Faculty of Forestry and Wood Technology, Mendel University, Brno, Czech Republic): Applied Geoinformatics in Forestry and Landscape Research Using Remote Sensing.

06.06.2011 – Martin Ligi (Tartu Ülikool): Naabrusefekti mõju satelliitsensori MERIS tulemitele.

06.10.2011 – Karlis Zalite: Remote sensing in Ventspils International Radio Astronomy Center (VIRAC).

28.10.2011 - Alo Eenmäe (Eesti MaaÜlikool): MODISe primaarproduktsiooni hinnangud Eesti erinevates metsatüüpides.

03.11.2011 - Tiit Nilson: Produktsioonimudelid ja kaugseire.

17.11.2011 - Kalju Eerme: Süsiniku tsükkel ja keskkonna tegurid.

15.12.2011 – Andres Kuusk: Hemiboreaalsete metsade lehepinnaindeksi hindamine.

9.3 Joint Seminar of the Observatory Observatooriumi ühisseminarid

31.01.2011 – Jouni Envall: Elektriline päikesepuri – uus projekt observatooriumis.

28.02.2011 – Marco Kirm (Tartu Ülikooli Füüsika Instituut): Tartu Ülikooli Füüsika Instituudi tegevuse tutvustamine.

28.03.2011 – Viljo Allik: Elektromagneetiline ühilduvus kaasaegsete elektroonikaseadmete projekteerimisel.

17.10.2011 – Enn Saar: Tippkeskusest.

21.11.2011 – Taavi Tuvikene: Tähtede heledusmuutlikkuse uurimine kaugjuhitavate teleskoopidega.

19.12.2011 – Joel Kuusk: Spektrimõõtmised INCREASE kllimamuutuse eksperimendi aladel.

10 Membership in scientific organizations
Teadusorganisatsioonide liikmed

Academia Europaea – J. Einasto
American Astronomical Society – J. Einasto
American Geophysical Union – K. Alikas (student member), J. Pisek, A. Reinart, S. Lätt (student member), K. Uudeberg (student member)
American Society of Photobiology – U. Veismann
ASTRONET Board – L. Leedjärv
Board of Directors "Astronomy and Astrophysics" – L. Leedjärv
Board of Member Countries Representatives of COST 726 Action – K. Eerme
Board of the Tartu Astronomy Club – E. Tago
British Interplanetary Society – U. Veismann
Editorial Board "Agricultural and Forest Meteorology" – A. Kuusk
Editorial Board "Baltic Astronomy" – T. Kipper
Editorial Board "Journal of Quantitative Spectroscopy and Radiative Transfer" – T. Viik
Editorial Board "Silva Fennica" – T. Nilson
Eesti Astronoomia Selts – K. Annuk, T. Eenmäe, J. Einasto, M. Gramann, A. Hirv, T. Liimets, T. Kipper, I. Kolka, L. Leedjärv, T. Nugis, J. Pelt, A. Puss, V.-V. Pustynski, M. Ruusalepp, L. Sapar, E. Tago, E. Tempel, T. Tuvikene, U. Veismann, T. Viik
Eesti Füüsika Selts – A. Aret, K. Eerme, J. Einasto, T. Kipper, L. Leedjärv, S. Lätt (board member), A. Reinart, E. Saar, A. Sapar, M. Sulev, P. Tenjes, T. Viik
Eesti Geofüüsika Komitee / Estonian Geophysical Committee – K. Eerme
Eesti Rahvuslik Astronoomia Komitee / Estonian National Committee on Astronomy – J. Einasto, L. Leedjärv (Chair), E. Saar, T. Viik
Eesti Kirjanduse Selts – U. Veismann
Eesti Kosmosepoliitika Töögrupp / Estonian Space Policy Working Group – L. Leedjärv (Vice-Chair), A. Reinart
Eesti Looduseuurijate Selts – K. Eerme, V. Russak, A. Sapar, M. Sulev, U. Veismann, T. Viik (president)
Eesti Teaduste Akadeemia / Estonian Academy of Sciences – J. Einasto, E. Saar, A. Sapar
EUFAR (EUropean Fleet for Airborne Research): Education and Training – S. Lätt
European Association of Remote Sensing Laboratories (EARSeL) – department of atmospheric physics
European Astronomical Society – K. Annuk, J. Einasto, M. Gramann, G. Hütsi, T. Kipper, I. Kolka, L. Leedjärv, V. Malyuto, T. Nugis, V.-V. Pustynski, E. Saar, A. Sapar, L. Sapar, I. Suhhonenko, E. Tago, P. Tenjes, U. Veismann, J. Vennik, T. Viik

European High Level Space Policy Group – L. Leedjärv
Euroscience – U. Veismann
Euro–Asian Astronomical Society – A. Aret, J. Einasto, V. Malyuto, V.-V. Pustynski, A. Sapar
Field Editor "Agronomie. Agriculture and Environment" – A. Kuusk
Finnish Society of Forest Sciences – M. Mõttus
The Gaia Data Processing and Analysis Consortium (DPAC), Coordination Unit CU8: Astrophysical Parameters – I. Kolka, V. Malyuto
German Astronomical Society – J. Einasto
Institute of Electrical and Electronical Engineers (IEEE) – S. Lätt (student member), J. Pisek (student member)
International Association for Great Lakes Research (IAGLR) – K. Alikas (student member)
The International Society for Optical Engineering (SPIE) – U. Veismann, S. Lätt (student member)
International Astronomical Union – K. Annuk, J. Einasto, M. Einasto, M. Gramann, U. Haud, G. Hütsi, T. Kipper, I. Kolka, L. Leedjärv, V. Malyuto, T. Nugis, J. Pelt, V.-V. Pustynski, E. Saar, A. Sapar, L. Sapar, I. Suhhonenko, E. Tago, A. Tamm, P. Tenjes, U. Veismann, J. Vennik, T. Viik
Marie Curie Fellowship Association – A. Reinart
MTÜ Euroscience Eesti – V.-V. Pustynski
Nordic Network on Physically-based Remote Sensing of Forests – T. Nilson (director), M. Lang (member of steering committee)
Optical Society of America – T. Viik, S. Lätt (student member)
Royal Astronomical Society – J. Einasto (associated member)
Ultraviolettkiirguse, osooni ja aerosoolide uurimise koordineerimise Eesti Nõukogu – K. Eerme, U. Veismann
Õpetatud Eesti Selts – U. Peterson, T. Viik
Working Group 4 of COST 726 Action – S. Lätt

11 Teaching and Popularizing Õppetöö ja popülariseerimine

11.1 Lecture courses and seminars Loengukursused ja seminarid

11.1.1 Astronomy Astronoomia

The Equations of Mathematical Physics *Matemaatilise füüsika võrrandid* – T. Viik, University of Tartu.
Global Physics, *Globaalfüüsika* – M. Gramann together with K. Eerme and K. Tarkpea, University of Tartu.
Advanced Seminar of Theoretical Physics Teoreetilise füüsika eriseminar – P. Tenjes, University of Tartu.
Astronomy *Astronoomia* – T. Sepp, University of Tartu.
Astronomy *Astronoomia* – P. Tenjes, University of Tartu.
General Astronomy *Üldine astronoomia* – P. Tenjes, University of Tartu.
Microworld Physics Mikromaailma füüsika – P. Tenjes, University of Tartu.
Seminar in Astrophysics *Astrofüüsika seminar* – T. Sepp together with P. Tenjes, University of Tartu.
Amateur Radio *Amatöörraadioside* – T. Eenmäe together with V. Allik, University of Tartu.
Space Technology *Kosmosetehnoloogia alused* – T. Eenmäe, University of Tartu.
Introduction to Astrophysics *Sissejuhatus astrofüüsikasse* – V.-V. Pustynski, Tallinn University of Technology.
Introduction to Space Flight *Sissejuhatus kosmonautikasse* – V.-V. Pustynski, Tallinn University of Technology.
General Course of Physics Füüsika üldkursus – V.-V. Pustynski, Tallinn University of Technology.
Physics II *Füüsika II* – V.-V. Pustynski, Tallinn University of Technology.
Introduction to Physics *Füüsika täiendõpe* – V.-V. Pustynski, Tallinn University of Technology.
Astronomy Course for the Nõo High School *Astronoomia kursus Nõo Reaalgümnaasiumi 12. klassidele* – K. Annuk, L. Leedjärv, E. Tempel, T. Viik.

11.1.2 Atmospheric physics Atmosfäärifüüsika

Introduction to Geophysics Sissejuhatus geofüüsikasse – K. Eerme, University of Tartu.
Environmental Science Keskkonnaõpetus – K. Eerme, University of Tartu.
Measurements and Measurement Uncertainty Mõõtmised ja mõõtemääramatused – E. Jakobson, University of Tartu (One general course and two separate courses for two different smaller groups of students).

Treatment of Measurement Data Mõõtmistulemuste töötlemine – E. Jakobson, University of Tartu.

Graphical Programming Visuaalprogrammeerimine – Aivo Reinart, University of Tartu.

Embedded Systems Manussüsteemid – Aivo Reinart, University of Tartu.

Real-time Systems Reaalajasüsteemid – Aivo Reinart, University of Tartu.

Data Acquisition and Analysis with LabVIEW Andmehõive ja analüüs LabVIEW keskkonnas – Aivo Reinart together with S. Vielhauer, University of Tartu.

Robot Design Project *Robootika projekt* – J. Kuusk (together with several other lecturers), University of Tartu.

Environmental Remote Sensing Keskkonnakaugseire – T. Nilson, K. Uudeberg, A. Kodar, University of Tartu.

Remote Sensing of Vegetation Taimkatte kaugseire – T. Nilson, University of Tartu.

Global Physics Globaalfüüsika – K. Eerme together with M. Gramann and K. Tarkpea, University of Tartu.

Computer-aided Measurements Arvutijuhitavad mõõtmised – I. Ansko, University of Tartu.

Image Processing in Remote Sensing Pilditöötlus kaugseires – U. Veismann together with A. Luts, University of Tartu.

Fundamentals of Remote Sensing Kaugseire alused – U. Peterson, University of Tartu.

Environmental Monitoring Keskkonnaseire – U. Peterson, Estonian University of Life Sciences.

Modelling of Environmental Processes and Spatial Analysis Looduslike protsesside modelleerimine ja ruumianalüüs – U. Peterson together with A. Kiviste, Estonian University of Life Sciences.

Remote Sensing in Nature Looduse kaugseire – M. Lang, Estonian University of Life Sciences.

Databases of Nature Resources Loodusressursside andmebaasid – M. Lang, Estonian University of Life Sciences.

Programming in C# and Pascal Programmeerimine C# ja Pascal keeles – A. Sims and M. Lang,
Estonian University of Life Sciences.

Geographic Information Systems Geograafilised Informatsioonisüsteemid – U. Peterson and M. Lang, Estonian University of Life Sciences.

Quality Management I Kvaliteetjuhtimine I – M. Noorma, University of Tartu.

Quality Management II Kvaliteetjuhtimine II – M. Noorma, University of Tartu.

Quality Management (in English) II Kvaliteetjuhtimine II – M. Noorma, University of Tartu.

Project and Quality Management (in English) Kvaliteedi- ja projektijuhtimine – M. Noorma, University of Tartu.

Space Technology Kosmosetehnoloogia alused – M. Noorma, University of Tartu.

Military Technologies Militaar- ja sisekaitsetehnoloogiad – M. Noorma, University of Tartu.

Space and Military Technology Seminar Militaar- ja sisekaitsetehnoloogia seminar – M. Noorma, University of Tartu.

Space Technology Project Kosmosetehnoloogia projekt – M. Noorma, University of Tartu.

11.2 Popular lectures Populaarteaduslikud loengud ja esinemised

2 intervjuud KUKU raadiole – K. Eerme.

Teleskoobivaatlus tänapäeval (Tartu Tähetorni Astronoomiaring, 18.01.2011) – T. Liimets.

Intervjuu Eesti tudengisatelliidi kohta ("Pealtnägija", 19.01.2011) – T. Eenmäe, M. Noorma.

Maad taevast ähvardavad ohud (Tartu Ülikooli dotsentide ja teadurite klubi, 20.01.2011) – T. Viik.

Ernst Knorre pojapojad ja Gustav Max Schmidti erakool Viljandis (Tartu Tähetorni Astronoomiaring, 01.02.2011) – T. Viik.

Maad taevast ähvardavad ohud (SA Tartu Ülikooli Kliinikum, 04.02.2011) – T. Viik.

Avalik vaatlusõhtud (Tartu Tähetorn, 07.02,2011; 08.02.2011) – A. Puss.

Eesti kosmoseteaduse prioriteetidest ja perspektiividest (intervjuu, ERR venekeelsed saated, 09.02.2011) – L. Leedjärv.

Tõsi-, usu- ja maitseasju meie aja astronoomias (Tartu Tähetorni Astronoomiaring, 15.02.2011) – E. Tago.

Vestlus tumedast Universumist ja säravatest tähtedest (AS Kodumajatehas, 18.02.2011) – L. Leedjärv.

Galaktikate tekkimisest (Tartu Tähetorni Astronoomiaring, 01.03.2011) – E. Tempel.

Tähtede ja planeetide tekkest (Tartu Ülikooli usuteaduskond, loengutsükkel "Algused ja lõpud", 02.03.2011) – L. Leedjärv.

BBC sarja "Seven Wonders of the Solar System" osa *Empire of the Sun* kommenteerimine (ETV2, 06.03.2011) – L. Leedjärv.

Avalik vaatlusõhtud (Tartu Tähetorn, 10.03,2011; 11.03.2011) – A. Puss.

BBC sarja "Seven Wonders of the Solar System" osa *Order Out of Chaos* kommenteerimine (ETV2, 13.03.2011) – T. Viik.

BBC sarja "Seven Wonders of the Solar System" osa *The Thin Blue Lines* kommenteerimine (ETV2, 20.03.2011) — I. Kolka.

Vaatlusprogramm "Kes näeb Merkuuri? (Tartu Tähetorni teaduslaager, 21.03,2011) – A. Puss.

Töötuba "Galileoskoop" (Tartu Tähetorni teaduslaager, 23.03,2011) – A. Puss.

Teleskooopide tutvustus (Tartu Tähetorni teaduslaager, Tartu, 23.03.2011) – A. Puss.

Teoreetiline ja praktiline aja-arvutus (Tartu Tähetorni Astronoomiaring, Tartu, 29.03.2011) – A. Puss.

Kui ohtlikud on meie kosmilised naabrid (Narva Lasteülikool, Tartu, 22.03.2011) – T. Viik.

Intervjuu kosmonautikapäeva puhul (ERR, 12.04.2011) – K. Eerme.

Teaduse helisõnastik – tume energia (Intervjuu Vikerraadio saates "Labor", 24.03.2011) – M. Gramann.

Tume Universum ja säravad tähed (loeng Eesti Lennuakadeemias, 24.03.2011) – L. Leedjärv.

BBC sarja "Seven Wonders of the Solar System" osa *Dead or Alive* kommenteerimine (ETV2, 27.03.2011) – T. Liimets.

Teoreetiline ja praktiline aja-arvutus (Tartu Tähetorni Astronoomiaring, 29.03.2011) – A. Puss.

BBC sarja "Seven Wonders of the Solar System" osa *Aliens* kommenteerimine (ETV2, 03.04.2011) – A. Tamm.

Kosmilistest gaasijugadest (Tartu Tähetorni Astronoomiaring, 05.04.2011) – L. Leedjärv.

Avalik vaatlusõhtu (Pala Kool, 13.04.2011) – T. Tuvikene, T. Eenmäe.

Kui ohtlikud on meie kosmilised naabrid (Narva Lasteülikool, Narva, 16.04.2011) – T. Viik.

Laviinid ja katastroofid maailmaruumis (Tartu Tähetorni Astronoomiaring, 19.04.2011) – J. Pelt.

Intervjuu NASA päikesetormi hoiatuse kohta (TV3 uudistesaade), 28.04.2011 – T. Eenmäe.

Tartu Tähetorni 200. aastapäeva teaduskonverentsist "Expanding the Universe" Galaktikate evolutsioon (intervjuu Vikerraadiole, Huvitaja, 29.04.2011) – E. Tempel.

Tartu Tähetorni 200. aastapäeva teaduskonverentsist "Expanding the Universe". (Intervjuu Vikerraadio saates "Labor", 01.05.2011) – L. Leedjärv.

Planetaariumietendused (Teaduskeskuse AHHAA püsiplanetaarium, kogu maikuu 2011) – A. Puss.

Planetaariumietendused planetaariumiga Starlab (Toosikannu, 06.06.2011) – A. Puss.

Sissejuhatus taimkattekaugseiresse (tellitud ettekanne) (Kaugseire suvekool, Nelijärve Puhkekeskus, 28.06.2011) – J. Pisek.

Välimõõtmised (Kaugseire suvekool, Nelijärve Puhkekeskus, 27.06.–29.06.2011) – J. Kuusk, J. Pisek.

Eksoplaneetide avastamise usutavus ja võimalikkus (Õpilaste Teadusliku Ühingu laager, Viitna, 07.08.2011) – T. Viik.

Avalikud vaatlusõhtud (Astronoomiahuviliste XVI üle-Eestiline kokkutulek, Pala, 10.08.–14.08.2011) – T. Tuvikene, T. Liimets.

Astronoomia reaalajas (Astronoomiahuviliste XVI üle-Eestiline kokkutulek, Pala, 11.08.2011) – T. Liimets.

Kaugvaatlused teleskoopidega: GRAS teadlasele ja huvilisele. Näidisvaatlus USAs New Mexicos asuva automaatse teleskoobiga. (Astronoomiahuviliste XVI üle-Eestiline kokkutulek, Pala, 12.08.2011) – T. Tuvikene.

Galaxy Zoo projekt teadlasele ja huvilisele (Astronoomiahuviliste XVI üle-Eestiline kokkutulek, Pala, 12.08.2011) – E. Tempel.

Supernoovadest (Astronoomiahuviliste XVI üle-Eestiline kokkutulek, Pala, 12.08.2011) – K. Tinn.

Kauguste redel astronoomias (Astronoomiahuviliste XVI üle-Eestiline kokkutulek, Pala, 12.08.2011) – T. Kuutma.

Galaktikatest superparvedeni (Astronoomiahuviliste XVI üle-Eestiline kokkutulek, Pala, 12.08.2011) – R. Kipper.

Vee leidumine Kuul (Astronoomiahuviliste XVI üle-Eestiline kokkutulek, Pala, 13.08.2011) – P. Tenjes.

Kuu tuhkvalgus (Astronoomiahuviliste XVI üle-Eestiline kokkutulek, Pala, 13.08.2011) – I. Kolka.

Apollo 11 pildistiku fotogrammeetria (Astronoomiahuviliste XVI üle-Eestiline kokkutulek, Pala, 13.08.2011) – V.-V. Pustynski.

Ülevaade eksoplaneetide avastamisest (Astronoomiahuviliste XVI üle-Eestiline kokkutulek, Pala, 14.08.2011) – T. Viik.

Kepleri missioon (Astronoomiahuviliste XVI üle-Eestiline kokkutulek, Pala, 14.08.2011) – J. Laur.

Nähtava Universumi tume(dam) külg (Astronoomiahuviliste XVI üle-Eestiline kokkutulek, Pala, 14.08.2011) – L. Leedjärv.

Millal maailma kaart valmis saab? (Astronoomiahuviliste XVI üle-Eestiline kokkutulek, Pala, 14.08.2011) – J. Pelt.

Avalik vaatlusõhtu (Tartu Tähetorni, 05.09.2011) – A. Puss.

Planetaariumietendused planetaariumiga Starlab (Tabivere Gümnaasium, 20.09.2011) – A. Puss.

Planetaariumietendused planetaariumiga Starlab (Tamme Gümnaasium, Tartu, 21.09.2011) – A. Puss.

Avalik vaatlusõhtu Teadlaste Ööl (Tartu Tähetorn, 23.09.2011) – A. Puss.

Avalik vaatlusõhtu (Tartu Tähetorn, 04.10.2011) – A. Puss.

Universum ja selle kujunemine (Eesti Looduseuurijate Selts, Tartu, 29.09.2011) – M. Gramann.

Meie kosmiline kodu (Nõo Põhikool, 4. klassid, 03.10.2011) – L. Leedjärv.

Universumi mustrid (Tartu Tähetorni Astronoomiaring, 04.10.2011) – T. Sepp.

Universumi paisumine ja supernoovad. Füüsika Nobel 2011 (intervjuu Vikerraadio saates "Labor", 06.10.2011) – M. Gramann.

Päikesesüsteemist galaktikate superparvedeni (Sänna Kultuurimõis, 07.10.2011) – E. Tempel.

Avalik vaatlusõhtu (Sänna Kultuurimõis, 07.10.2011) – E. Tempel, T. Tuvikene.

Neutrontähed (Tartu Tähetorni Astronoomiaring, 18.10.2011) – A. Puss.

Meie kosmiline kodu (Nõo Põhikool, 1. klassid, 20.10.2011) – L. Leedjärv.

Avalik vaatlusõhtu (Sänna Kultuurimõis, 21.10.2011) – T. Tuvikene, E. Tempel.

Päikesesüsteemi uurimine automaatjaamadega – hetkeseis (Sänna Kultuurimõis, 21.10.2011) – T. Tuvikene.

Astronoomiatunnid Saaremaa Ühisgümnaasiumis. Projekt "Tagasi kooli" (Kuressaare, 21.10.2011) – A. Puss.

Teleskoobivaatlus tänapäeval (Sänna Kultuurimõis, Sänna, 04.11.2011) – T. Liimets.

Avalik vaatlusõhtu (Sänna Kultuurimõis, 04.11.2011) – T. Tuvikene, T. Liimets, A. Tamm, J. Laur.

BBC sarja "Wonders of the Universe" osa Destiny kommenteerimine (ETV2, 06.11.2011) – L. Leedjärv.

BBC sarja "Wonders of the Universe" osa Stardust kommenteerimine (ETV2, 13.11.2011) – T. Liimets.

Kohtumine teadlastega (Tartu Ülikooli Ajaloo Muuseum, 14.11.2011) – J. Einasto.

GK Persei – ilutulestiku noovajäänuk (Tartu Tähetorni Astronoomiaring, 15.11.2011) – T. Liimets.

Tähistaevas selgeks Planetaristide kursus, Tartu, 19.11.2011 – A. Puss.

Päikese, Kuu ja planeetide liiikumine ruumis ning taevasfääril Planetaristide kursus, Tartu, 19.11.2011 – A. Puss.

Tänapäeva täheteadus: tähed Planetaristide kursus, Tartu, 20.11.2011 – A. Puss.

BBC sarja "Wonders of the Universe" osa *Falling* kommenteerimine (ETV2, 20.11.2011) – A. Tamm.

Muistsete eestlaste tähistaevas (Nõo päevakeskus, 22.11.2011) – M. Ruusalepp.

Vestlus astronoomiast, muusikast, luulest ja muust (Teaduskabaree, Tallinn, 24.11.2011) – L. Leedjärv.

Meie kosmiline kodu (Kallavere Keskkool, 25.11.2011) – L. Leedjärv.

Planetaariumietendused AHHAA püsiplanetaariumis (Tartu, 27.11.2011) – A. Puss.

Tähistaeva vaatlused Galileoskoobiga (Tartu Tähetorni Astronoomiaring, 29.11.2011) – T. Tuvikene.

Tartu Tähetorni Zeissi teleskoobi ning planetaariumi tutvustus (Vikerraadio, 30.11.2011) – A. Puss.

Friedrich Wilhelm August Argelander ja Soome astronoomia alguspäevad (Tartu Tähetorni Astronoomiaring, 06.12.2011) – T. Viik.

Maailma loomine (Sänna Kultuurimõis, Sänna, 09.12.2011) – J. Pelt.

Tartu Tähetorni Zeissi teleskoobi ning planetaariumi tutvustus (Vikerraadio lastesaade, 06.12.–07.12.2011) – A. Puss.

Planetaariumietendused AHHAA püsiplanetaariumis (Tartu, 10.12.2011) – A. Puss.

Valgusreostus ja tähevaatlused (Õpilaste juhendamine ja loeng) (Loodusteaduste kool, Tõraveres, 14.12.2011) – T. Eenmäe.

Mis on eksoplaneedid ja kuidas neid avastatakse? (Eesti Looduseuurijate Selts, Tartu, 15.12.2011) – T. Viik.

Uut astronoomias (Miina Härma Gümnaasium, Tartu, 14.12.2011) – E. Tempel.

1,5m teleskoobi moderniseerimisest (Intervjuu Aktuaalsele Kaamerale, 26.12.2011) – K. Annuk.

11.3 Theses defended, supervised and refereed by the staff of the Observatory Observatooriumi töötajate poolt kaitstud, juhendatud ja oponeeritud väitekirjad

11.3.1 Ph.D. theses Doktoritööd

E. Tempel: Tracing Galaxy Evolution by Their Present-day Luminosity Function. Galaktikate evolutsiooni mõistmine nende heledusfunktsiooni abil. Ph.D. Thesis, University of Tartu.
Defence Kaitsmine: 03.06.2011.
Supervisors Juhendajad: E. Saar, P. Tenjes (Tartu Observatory).
Opponents Oponendid: Prof Emeritus Mauri Valtonen (University of Turku), T. Viik (Tartu Observatory).

J. Kuusk: Measurement of Top-of-Canopy Spectral Reflectance of Forests for Developing Vegetation Radiative Transfer Models. Metsade atmosfäärialuse spektraalse peegelduskoefitsiendi mõõtmine taimkatte kiirguslevimudelite arendamiseks. Ph.D. Thesis, University of Tartu.
Defence Kaitsmine: 24.08.2011.
Supervisors Juhendajad: A. Kuusk (Tartu Observatory), M. Noorma (University of Tartu).
Opponents Oponendid: Dr. Jouni Peltoniemi (Finnish Geodetic Institute, Finland), Dr. T. Kõuts (Institute of Marine Systems, Tallinn University of Technology, Estonia).

A. Hirv: Estimation of Time Delays from Light Curves of Gravitationally Lensed Quasars. Gravitatsiooniläätsest põhjustatud kvasarite mitmikkujutiste vaheliste ajanihete mõõtmine. Ph.D. Thesis, University of Tartu.

Defence Kaitsmine: 26.08.2011.
Supervisor Juhendaja: J. Pelt (Tartu Observatory).
Opponents Oponendid: Prof. Lutz Wisotzki, Leibniz-Institut für Astrophysik (AIP), Potsdam, Germany. Prof. dr. Luitje Vincent Ewoud Koopmans, Kapteyn Astronomical Institute, Groningen, the Netherlands.

11.3.2 M.Sc. theses Magistritööd

K. Eerme – *I. Biduljak*: The Influence of Civil Aircrafts on the Area of Tallinn Airport and Climate. Reisilennukite mõju Tallinna Lennujaama piirkonnale ja kliimale (M. Sc.), University of Tartu.

J. Pelt – *J. Laur*: Katikupõhine mõõteskeem ülikiires fotomeetrias. Shutter Based Fast Photometry for Faint Objects (M.Sc.), University of Tartu.

Opponent Oponent: I. Kolka.

Anu Reinart – *M. Ligi*: Naabrusefekti mõju satelliitsensori MERIS tulemitele Impact of Adjacency Effect to Satellite Sensor MERIS Products2 (M.Sc.), University of Tartu.

M. Lang – *T. Arumäe*: Laserskanneri andmete kasutamine takseertunnuste hindamiseks. Using LIDAR Data to Assess Forest Characteristics. (M.Sc.), Estonian University of Life Sciences.

Opponent Oponent: U. Peterson.

M. Lang – *R. Rämonen*: Vegetatsiooniperioodi muutuste kasutamine metsade kaardistamiseks satelliidipiltidelt. Using Seasonal Changes in Forest Spectral Signature to Predict Inventory Variables. (M.Sc.), Estonian University of Life Sciences.

Opponent Oponent: U. Peterson.

Aivo Reinart – *T. Ginter*: Multispektraalse ruumhajumismõõtja riistvara ja tarkvara funktsionaalne ning arhitektuuriline disain. Functional and Architectural Design of Multispectral Volume Scattering Meter Hardware and Software (M.Sc.), University of Tartu.

Opponent Oponent: I. Ansko.

M. Lang, T. Nilson – *A. Eenmäe*: MODIS'e primaarproduktsiooni hinnangud Eesti erinevates metsatüüpides. MODIS Primary Production Estimates in Different Forest Types of Estonia. (M.Sc.), Estonian University of Life Sciences.

Opponent Oponent: U. Peterson.

T. Nilson – *R. Belov*: CORINE'i maakattetüüpide kiirgustemperatuurid Landsat 7 soojuskanali piltidelt. Radiation Temperatures of CORINE Landcover Classes as Measured from LANDSAT 7 Images. (M.Sc.), Estonian University of Life Sciences.

V. Allik, M. Noorma – *M. Pelakauskas*: ESTCube-1 satelliidi elektrisüsteemi energiasalvestuse alamsüsteemi kavandamine, ehitamine ja testimine. ESTCube-1 Electrical Power System Battery Subsystem Design and Testing. (M.Sc.) University of Tartu.

M. Noorma – *R. Rantsus*: ESTCube-1 päikeseenergia kogumise süsteemi kavandamine, teostamine ja katsetamine. Designing, Implementing and Testing the Solar Power Harvesting System for ESTCube-1. (M.Sc.) University of Tartu.

M. Noorma – *T. Tilk*: Akustilise signaali leviaja mõõtmisel põhinev lokaliseerimise süsteem. Localization System Based on Acoustic Signal Time Difference of Arrival. (M.Sc.) University of Tartu.

Opponent Oponent: Aivo Reinart.

V. Allik – *T. Vahter*: ESTCube-1 pikosatelliidi saatja võimsusvõimendi ja vastuvõtja madalamüralise eelvõimendi prototüüpide disainimine. STCube-1 picosatellite receiver low noise amplifier and transmitter power amplifier prototype designing (M.Sc.) Tallinn University of Technology.

11.3.3 B.Sc. theses Bakalaureusetööd

V. Allik, S. Lätt, T. Eenmäe – *I. Sünter*: ESTCube-1 satelliidi kiirguskindel käsu- ja andmehaldussüsteemi riistvara. Radiation Tolerant Hardware Design for ESTCube-1 Command and Data Handling System (B.Sc.), University of Tartu.

M. Noorma – *A. Leitu*: ESTCube-1 toitesüsteemi disainimine, väljatöötamine ja testimine. Designing, Implementing and Testing the Power Distribution System for ESTCube-1 (B.Sc.), University of Tartu.

K. Eerme – *A.Vastsenko*: Pilvisuse mõju maapinnale langevale ultraviolettkiirguse spektraalsele kiiritustihedusele. Influence of cloudiness on the ground-level ultraviolet spectral irradiance (B. Sc.), Estonian Marine Academy.

M. Lang – *M. Loodus*: Järvselja 1969. aasta aerofotode andmebaasi digitaliseerimine. Digitalisation of Aerial Photographs of Järvselja 1969 (B.Sc.), Estonian University of Life Sciences.

Aivo Reinart – *A. Puussaar*: Multispektraalse ruumhajuvusmõõtja nõuded ja analüüs. Requirements and Analysis of Multispectral Volume Scattering Meter (B.Sc.), University of Tartu.

T. Viik – *T. Kelder*: Pärandkultuuri objektid – kivilabürindid ja ohvrikivid. The Objects of Cultural Heritage – Stone Labyrinths and Sacrificial Stones. (B.Sc.), Estonian University of Life Sciences.

11.3.4 Refereeing of theses Oponeerimine

V. Allik – *A. Vahter*: Digital Electronics and Software Design for the Communication Subsystem of the ESTCube-1 Cube Satellite.Kuupsatelliidi ESTCube-1 kommunikatsiooni alamsüsteemi digitaalelektroonika ja tarkvara disain(M.Sc.), Tallinn University of Technology.

K. Eerme – *S. Mirme*: Development of Nanometer Aerosol Measurement Technology Nanomeeter-aerosooli mõõtmistehnoloogia arendamine (Ph.D.), University of Tartu.

U. Veismann – *I. Biduljak*: The Influence of Civil Aircrafts on the Area of Tallinn Airport and Climate.Reisilennukite mõju Tallinna Lennujaama piirkonnale ja kliimale (M.Sc.), University of Tartu.

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