Contents Sisukord

Eessõna

2009 oli Rahvusvaheline Astronoomia Aasta. Kahjuks tõi see aasta eesti keelde ka uue sõna: masu ehk majandussurutis. Tagasivaates näib, et Tartu Observatoorium tuli sellest langusaastast siiski suhteliselt väikeste kaotustega läbi. Võib-olla võinuks Rahvusvahelise Astronoomia Aasta tähistamine paremates majandusoludes veel suurejoonelisem ja väljapaistvam olla, aga sellegipoolest olid meie astronoomid, eriti nooremad, väga tublid. Avalikud vaatlusõhtud, nii Tõravere suure teleskoobi juures kui kaasaskantava teleskoobiga paljudes muudes Eestimaa paikades, saavad loodetavasti uueks traditsiooniks. Kahjuks aga ei laabunud möödunud aastal koostöö ilmataadiga kuigi hästi. Huvi astronoomiliste piltide näituse vastu on jätkunud ka 2010. aastasse. Kindlasti jätkavad meie astronoomid ja atmosfäärifüüsikud tavapäraseid teaduse populariseerimise tegevusi (artiklid, loengud, ekskursioonide vastuvõtmine jne) ning tahaks loota, et tulevikus saab sellist aktiivsust ka materiaalselt paremini kompenseerida.

Teaduse areng läheb oma rada pidi edasi, paar kehva aastat ei tohiks selle järjepidevust väärata. 2010. aastal saame riigieelarvest igapäevase elamise raha veel veidi vähem kui mullu. Samas on käima pandud mitmed programmid-projektid-meetmed, tänu millele saame näiteks uut teadusaparatuuri muretseda. Rahalugemisest keerukamaks võib osutuda hoopis peahoone renoveerimine ja laiendamine, mis peaks 2010. aastal algama. See lööb kõigi inimeste harjumuspärase töörütmi mõneks ajaks segi, aga usun, et tulemus on seda ajutist segadust väärt. Selle eest, et Tõraveres asuks parimate töötingimustega kaasaegne kosmoseuuringute keskus, hoolitseb aga juba aprillis 2010 ametisse asuv uus direktor. Minule on 11 direktori-aastat olnud parajalt pikk, töörohke ja huvitav aeg, mille läbitegemise eest olen tänulik kõigile kolleegidele, koostööpartneritele, ministritele ja teistele ametnikele, sõpradele. Soovin oma järeltulijale jõudu ja edu – muuhulgas ka uute aastaraamatute kokkupanemiseks.

Laurits Leedjärv
Direktor

Tõraveres
veebruar 2010

Foreword

The year 2009 was an International Year of Astronomy. Unfortunately, it coincided with the year of economic crisis in Estonia (and in most of the world). In retrospective, however, it seems that Tartu Observatory survived this year without major disruptions. Maybe celebrations of the International Year of Astronomy could have been more ambitious and notable in better economic conditions. Nevertheless, our astronomers, especially younger ones, put a great effort into the activities of IYA2009. Hopefully, it becomes a new tradition to arrange public observing nights both at Tõravere on the biggest telescope and in many different places over Estonia, using the portable telescope. Unfortunately, we were not able to arrange a good weather for most of the public nights. There has been ever continuing interest for the exhibition of astronomical photographs. Certainly, our astronomers and atmospheric scientists will continue their conventional popularization activities, like articles, lectures, excursions etc.

Evolution of science goes along its inherent way which should not be disturbed by a couple of economically unfavourable years. Although in 2010 direct allocations from the state budget for our everyday life will again be a little bit less than in the last year, there are other programmes and activities which allow, for example, to buy a new scientific equipment. The expected renovation and extension of the main building could become even more disturbing for the Observatory in 2010 than minor cuttings from the budget. This will influence everybody working in our building, but I am sure that the result would be worth of this temporary confusion. Starting from April 2010, a new director will take care for developing a modern space research centre at Tõravere. After 11 years in this job, I would like to thank all colleagues, collaboration partners, ministers and other officers, and just friends for this fruitful and interesting time – and to wish success and endurance to my successor.

Laurits Leedjärv
Director

Tõravere
February 2010

1 Ülevaade

1.1 Uurimisteemad ja grandid

1.1.1 Sihtfinantseeritavad teadusteemad

2009. aastal jätkus Tartu Observatooriumis eelmisel aastal avatud sihtfinantseeritavate teadusteemade täitmine. Esialgu määratud summasid vähendati aasta keskel vastuvõetud negatiivse lisaeelarvega 4% võrra.

- Tumeenergia, tumeaine ja struktuuri teke Universumis (teema juht E. Saar) – 3 571 776 EEK,
- Evolutsiooni hilisfaasis tähtede ja nende ümbriste vaatluslik ja teoreetiline uurimine (teema juht T. Kipper) – 4 651 584 EEK,
- Optiliselt keerukate looduskeskkondade kaugseire (teema juht A. Kuusk) – 1 002 720 EEK.

(1 kEEK = 1000 EEK = 63.9 EUR)

1.1.2 Eesti Teadusfondi grandid

Sihtasutus Eesti Teadusfond rahastas 13 granti, mida samuti aasta keskel 4% võrra vähendati:

- Grant 6810: I. Kolka – Suure kiirgusvõimsusega kaugelearenenud tähed kosmoseteleskoobi Gaia objektidena – 135 360 EEK.
- Grant 6812: M. Mõttus – Hüperspektraalsete ja mitme vaatenurga alt mõõdetud kaugseireandmete kasutamisvõimalused metsa struktuuri hindamiseks – 167 904 EEK.
- Grant 6813: J. Pelt – Dispersioonispektrite teooria ja rakendused – 76 800 EEK.
- Grant 6814: A. Reinart – Satelliitkaugseire meetodite arendamine Eesti optiliselt mitmekomponendiliste veekogude uurimiseks – 239 040 EEK.
- Grant 6815: T. Nilson – Eesti metsade produktiivsuse monitooring satelliitkaugseire abil – 196 800 EEK.
- Grant 7115: A. Tamm – Ketasgalaktikate evolutsioon kosmoloogilistel ajaskaaladel – 55 200 EEK.
- Grant 7137: K. Eerme – Päikese ultraviolettkiirguse spektraalne koostis maapinnal – 96 000 EEK.
- Grant 7146: M. Gramann – Galaktikate evolutsioon ja tume energia paisuvas Universumis – 88 320 EEK.
- Grant 7691: V.-V. Pustynski – Füüsikalised protsessid, statistilised omadused ja evolutsiooniline areng kuumade allkääbustega kaksiksüsteemides – 67 200 EEK Tartu Observatooriumile.
- Grant 7725: A. Kuusk – Metsa peegeldusindikatriss – 288 000 EEK.

- Grant 7765: U. Haud – Nähtav ja varjatud aine galaktikates – 153 600 EEK.
- Grant 8005: E. Saar – Valguskoonused: kosmiliste struktuuride areng – 268 800 EEK.
- V. Russak oli üks põhitäitja TÜ dotsendi H. Ohvrili grandis nr. 7347 (57 600 EEK Tartu Observatooriumile) ja T. Tomsoni grandis nr. 7332.

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

Alates 2008. aastast annab Eesti Teadusfond välja ka järeldoktorite grante. Kaks taotlejat töötasid 2009. aastal Tartu Observatooriumis:

- ETF järeldoktori grant JD 107 (01.01.–31.08.2009): Abdelaziz Kallel – Taimkatte kiirguslevi modelleerimine: liitmismeetodi täiendamine ja kontroll – 275 000 EEK.
- ETF järeldoktori grant JD 131 (01.01.–31.12.2009): M. Saal – Üldistatud gravitatsiooniteooriate teoreetilised ja kosmoloogilised aspektid – 324 500 EEK.

1.1.3 FP7 projekt EstSpacE

Jätkus EL 7. raamprogrammi projekt EstSpacE (Eesti kosmoseuuringute ja -tehnoloogia võimekuse avamine partnerluse kaudu tipptasemel Euroopa teadusasutustega). Projekti juht on A. Reinart, kestvus kolm aastat (01.03.2008–28.02.2011), Euroopa Komisjoni finantseering kokku *ca* 1.1 MEUR (17.206 MEEK), millest 2009. aastal laekus 5448.7 kEEK. Projekti tegevustest 2009. aastal tuleb juttu Aastaraamatu vastavates osades.

1.1.4 Muid projekte ja lepinguid

- Deklareeritud põllupindade kontroll kaugseirevahenditega. Teadus- ja arendusleping PRIA-ga: U. Peterson – 40 000 EEK.
- Satelliitide tulemite parandamine kasutamiseks suurte järvede kaugseires. EMP1 2008: A. Reinart – 323 350 EEK.
- Riikliku keskkonnaseire programmi allprogramm "Eesti maastike muutuste uuringud ja kaugseire": U. Peterson – 200 000 EEK.
- Kosmosepõhised rakendused Euroopa teenistuses/GMES andmete integratsioon, harmoneerimine, kasutamine ja edastamine. Ettevõtluse Arendamise Sihtasutus 2008–2009: U. Peterson – 139 830 EEK.
- MERIS-e produktide Vänerni järvel ja Balti mere loodeosa rannikuvetel testimise tehniline tugi. ESA/ESRIN projekti alamprojekt, leping Stockholmi Ülikooliga, nr. 21524: A. Reinart – 60 996 EEK.

- Satelliidiandmete kasutamine vetikate massiõitsengute hindamiseks ja prognoosimiseks. Teadus-arendusleping Rootsi Meteoroloogia ja Hüdroloogia Instituudiga, Leping nr. 2007/2213/43, 2009–2010: TO koordinaator A. Reinart – 139 960 EEK.
- Põhjamaade vee kaugseirevõrgustik (NordAquaRemS). Leping nr. 080106: A. Reinart – 154 136 EEK.
- Kosmoseterminoloogia arendamine. Eesti Terminoloogia Ühing. Leping nr. 02-14/2008: U. Veismann – 10 000 EEK.

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

1.2 Töötajad

30. aprillil 2009 jäi pensionile observatooriumi kauaaegne pearaamatupidaja Liidia Meier. Alates 1. maist on pearaamatupidaja Külli Kärner.

Majanduslikult raske aeg sundis 2009. aastal mõne inimese töökoormust vähendama, kuid päris koondama õnneks kedagi ei pidanud. Saime hoopis uusi inimesi juurde võtta – seda peamiselt tänu FP7 projektile EstSpacE.

Alates 1. maist töötab 0.3 koormusega vanemteadurina Mart Noorma, 1. oktoobrist teadurina Aivo Reinart ja vanemteadurina Jan Pisek. Tema on Tšehhi kodanik, kes tuli meile külalisteadlaseks Torontost. Alates 1. novembrist on samuti EstSpacE'i teadlasena Eestis tagasi Gert Hütsi.

Kosmoloogia osakonnas töötab alates 1. maist 0.5 inseneri kohal Ingrid Enkvist. Atmosfäärifüüsika osakonna vanemteaduri Matti Mõttuse tööleping on 1. juulist peatatud, ta töötab praegu Soomes. 31. augustil soovis sama osakonna järeldoktor Abdelaziz Kallel oma töölepingu ennetähtaegselt lõpetada, sest ta valiti oma kodumaal Tuneesias professoriks. Alates 1. jaanuarist 2010 töötab Eesti Teadusfondi grandi toel järeldoktorina Erko Jakobson.

6. aprillil 2009 lõppes direktor Laurits Leedjärve töölepingu tähtaeg. Kuna varem välja kuulutatud avalikul konkursil ühtegi avaldust direktori kohale ei laekunud, kuulutas teadusnõukogu konkursi nurjunuks ja palus Haridus- ja Teadusministeeriumil pikendada Laurits Leedjärve töölepingut veel üheks aastaks.

Teoreetilise astrofüüsika töörühma teadur Anna Aret kaitses 5. juunil 2009 Tartu Ülikoolis edukalt doktoriväitekirja.

Kõigi muutuste tulemusena oli 1. jaanuaril 2010 Tartu Observatooriumis tööl 78 inimest, neist 48 teadustöötajat ja 9 teadustööd tegevat inseneri.

1.3 Tunnustused

Rahvusvaheline Relativistliku Astrofüüsika Keskus (ICRA, Itaalia) ja sellega seotud teadusinstituutide võrgustik ICRANet annavad välja Marcel Grossmanni auhinda väljapaistvate saavutuste eest teoreetilise füüsika ja kosmoloogia alal. Auhind on väga prestiižne, selle saajate hulgas on mitmeid Nobeli preemia laureaate. 2009. aasta auhind omistati akadeemik Jaan Einastole tema teedrajava panuse eest tumeaine ja kosmilise kärgstruktuuri avastamisel ning teadustöö edendamisel ajaloolises Tartu Observatooriumis. Koos J. Einastoga said Marcel Grossmanni auhinna ka Christine Jones galaktikate ja galaktikaparvede röntgenkiirguse uurimise eest ja Michael Kramer saavutuste eest pulsarite füüsikas. Auhinnad anti kätte 12. Marcel Grossmanni konverentsi avapäeval 12. juulil 2009 Pariisis UNESCO peakorteris.

Jaan Einasto tähistas 2009. aastal 80. sünnipäeva. Vahetult enne seda sai ta taevasse omanimelise asteroidi – Rahvusvaheline Astronoomiaunioon kinnitas väikeplaneedi 11577 nimeks Einasto. Sünnipäeva puhul avati Tartu Ülikooli raamatukogus näitus ”Per aspera ad astra”.

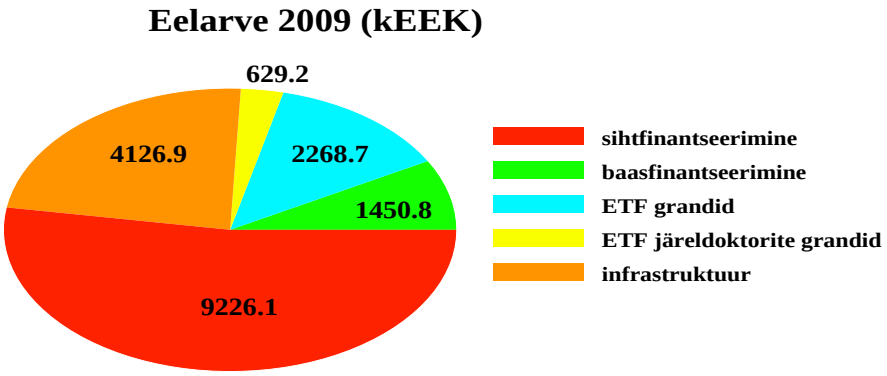
Eesti Teaduste Akadeemia, Haridus- ja Teadusministeerium ja Sihtasutus Archimedes korraldasid järjekordse teaduse populariseerimise konkursi, kus I auhinna sai aastatel 2000 – 2008 avaldatud populaarteaduslike artiklite eest Uno Veismann.

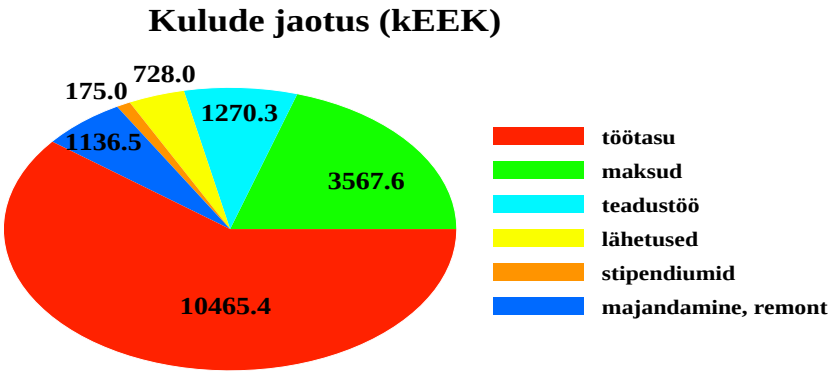
Eesti Rahvuskultuuri Fondi Heino Eelsalu allfondi stipendiumi sai Tõnu Tuvikene Tartu Tähetorni Astronoomiaringi töö juhtimise eest.

1.4 Eelarve

Riigieelarvest eraldati Tartu Observatooriumile 2009. aastal 17.7482 miljonit krooni. Selle summa sees on ka 46.3 kEEK õppelaenude kustutamiseks, mis ei kajastu järgnevates diagrammides.

Tulud ja kulud jagunesid järgnevalt:





Lisaks laekus *ca* 7024 kEEK mitmesugustest koostööprojektidest ja lepingutest, mida on nimetatud osades 1.1.3 ja 1.1.4.

Observatooriumi teadlaste (sh. EstSpacE projekti teadlased) keskmine töötasu 2009. a lõpul oli 18 944 EEK (*ca* 1210 EUR) kuus.

1.5 Aparatuur ja seadmed

Projekti EstSpacE raames muretseti 2008. aastal palju uusi teadusinstrumente, millest mõne katsetamine ja töölerakendamine jätkus veel 2009. aastal, näiteks:

- Portatiivne välispektromeeter SVC HR-1024 (Spectra Vista Corporation) taimkatte kaugseireks.
- Spektromeetriline süsteem päikese ultraviolettkiirguse mõõtmiseks (baseerub topeltmonokromaatoril Bentham DMc150F-U) seati üles termostateeritud Envirobox kambris EMHI Tartu-Tõravere meteoroloogiajaamas.
- CCD kaamera Andor iKon-L baasil hakkas firma Protolab (Tartu) ehitama tähefotomeetrit 0.6 m teleskoobi jaoks.

1.5 m teleskoobi juurde osteti uus gideerimiskaamera ST-402ME.

1.5 m teleskoobiga tehti spektraalvaatlusi 32 ööl ning 0.6 m teleskoobiga fotomeetrilisi vaatlusi vaid 2 ööl – 2009. aasta jääb meelde väga kehvade vaatlusilmadega.

1.6 Teadusnõukogu töö

Tartu Observatooriumi teadusnõukogu on 13-liikmeline. 2009. a selle koosseis ei muutunud. Nõukogu esimees on direktor Laurits Leedjärv ja aseesimees vanemteadur Tõnu Viik. Väljastpoolt Observatooriumi kuuluvad nõukogusse Riigikogu esimees akadeemik Ene Ergma ja Tartu Ülikooli professor Rein Rõõm. Haridus- ja Teadusministeeriumi poolt määratud liige on Tartu Ülikooli dotsent Peeter Tenjes.

Teadusnõukogu pidas 10 koosolekut, kuulati järgmisi teaduslikke ettekandeid:

Jaanuar – *A. Tamm*: Tolm kosmoses.
Veebruar – *M. Mõttus*: Uued võimalused taimkatte kaugseires: hüperspektraalsed mõõtmised ja mitu vaatenurka.
Märts – *M. Gramann*: Galaktikad ja tume energia.
Aprill – *Vladislav-Venjamin Pustõnski*: Massikao tempost EHB eellastes.
Juuni – *K. Annuk*: Kuumad tähed – üksinda, kahekesi, mitmekesi.
September – *J. Laur*: Kiirete protsesside fotomeetria nõrkade vaatlusobjektide jaoks.
– *L.J. Liivamägi*: SDSS DR7 põhi- ja LRG-de valimite superparvede kataloog.
– *M. Prüssel*: Tõraveres mõõdetud UV kiirguse spektri sõltuvus pilvisusest.
November – *A. Kuusk, M. Lang, J. Kuusk*: Andmebaas metsa kiirguslevi mudelite testimiseks.
Detsember – *M. Einasto*: Galaktikasüsteemide morfoloogiast.

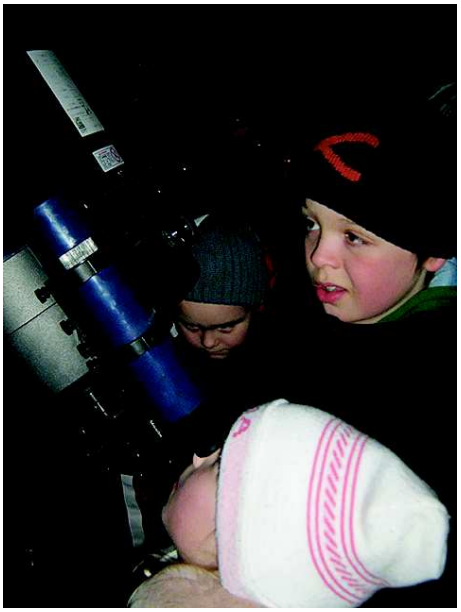
Muid teadusnõukogu tegemisi:

- 23. märtsil kinnitati lõppenud ETF grantide aruanded. Lõppesid A. Kuuse, E. Saare, A. Sapari, J. Venniku grandid. Samal koosolekul otsustati esitada Haridus- ja Teadusministeeriumile taotlus, et direktor Laurits Leedjärv töötaks kuni 6. aprillini 2010 direktori kohusetäitjana.
- 27. aprillil kinnitati U. Petersoni poolt esitatud Keskkonnaministeeriumiga sõlmitud seiretööd käsitleva lepingu lõpparuanne.
- 25. mail esitati vanemteadur Enn Saare kandidatuur Eesti Teaduste Akadeemia akadeemikuks täppisteaduste alal kandideerimiseks. Koosolekul toimus ka diskussioon observatooriumi infrastruktuuri arendusprojekti üle. Nõukogu volitas direktsiooni välja kuulutama ideekonkursi nimetatud arendusprojekti kohta.
- 21. septembri koosolekul määrati kolmele noorele inimesele stipendiumid. E.J. Öpiku nimelised stipendiumid said TÜ magistrant Jaan Laur ja TÜ doktorant Lauri Juhan Liivamägi. J. Rossi nimeline stipendium määrati TÜ doktorant Margit Prüsselile.
- 12. oktoobril toimus sihtfinantseeritavate teadusteemade jätkutaotluste ja väikesemahulise aparatuuri taotluste arutelu ja kinnitamine.
- 9. novembril arutati keskmise maksumusega teadusaparatuuri kaasajastamise taotlust ning võeti vastu otsus, et esitatakse kaks projekti – 1.5 m teleskoobi juhtimissüsteemi moderniseerimine ja kaugseire etalonide komplekslabor koos peegeldusetaloniga. Mõlema projekti maksumus võiks olla 2.9 MEEK.
- 7. detsembril otsustati A. Kuuse, M. Langi ja J. Kuuse tööd esitada riigi teaduspreemia saamiseks täppisteaduste valdkonnas.

1.7 Suhted avalikkusega

Aasta 2009 oli ÜRO otsusega kuulutatud Rahvusvaheliseks Astronoomia Aastaks (RAA2009). See andis meile võimaluse ja kohustuse tegeleda senisest veelgi ulatuslikumalt teaduse populariseerimisega. Eestis oli RAA2009 ürituste koordineerijaks vanemteadur Kalju Annuk, kes osales ka RAA2009 avatseremoonial UNESCO peakorteris Pariisis (koos Mare Ruusalepaga) ja lõpetamisel Padovas. RAA2009 üritusi korraldasid Tartu Tähetorni Astronoomiaring, AHHAA keskus, ühendus "Ridamus", MTÜ Stellaarium jt. Observatooriumi teadlaste poolt tehtu on üksikasjalikult kirjas osas 11.3 lk. 93, loengud, intervjuud jm. osas 11.2 lk. 89.

Jätkuvalt külastas Tõraveret palju ekskursioone: 233 gruppi rohkem kui 5100 huvilisega. Nüüdsest saab ülevaate registreeritud ekskursioonidest observatooriumi koduleheküljelt. Traditsiooniliselt peeti astronoomia loenguid Nõo Reaalgümnaasiumi 12. klasside õpilastele.



Tõraveres toimus 12.–16. augustini ka traditsiooniline astronoomiahuviliste kokkutulek, kus osales *ca* 100 inimest. Kokkutuleku juhtteema oli "400 aastat teleskoope ja 200 aastat taeva uurimist Eestis".

Observatooriumi teadlaste arvukad populaarteaduslikud kirjutised on üksikasjaliselt ära toodud lk. 65, avalikud loengud ja intervjuud lk. 89.

Ilmus Tähetorni Kalender 2010 (86. aastakäik) ja juba traditsioonine Tähistaeva Kalender 2010.

RAA2009 sisse jäi ka mahuka entsüklopeedilise teatmeteose "Tähistaevas" (576 lk.) avaldamine kirjastuse "Koolibri" poolt. Selle raamatu tõlkisid 2008. aastal Peeter Einasto, Indrek Kolka, Laurits Leedjärv ja Antti Tamm.

Jaan Pelt digitaliseeris Tartu Observatooriumi Publikatsioonide väljaanded 1–30, aastatest 1817–1940. Rohkem kui 8000 lehekülge ajaloolisi dokumente on PDF formaadis kättesaadavad Tartu Observatooriumi Virtuaalses Muuseumis.

Tartu Tähetorn sada aastat tagasi. Foto observatooriumi publikatsioonide XXIV köitest.

Observatooriumi tegevuse tutvustamiseks alustati koduleheküljel pressiteadete ja teadusuudiste avaldamist. Teadusuudised põhinevad ilmunud teadusartiklitel ja kajastavad Observatooriumis tehtava teadustöö olulisemaid tulemusi.

Koostöös Eesti Astronoomia Seltsiga loodi Taavi Tuvikese algatusel keskne astronoomia-alane veebileht "Astronoomia.ee – värav Eesti astronoomiasse". Veebilehe olulisemateks osadeks on uudiseid ja teateid kajastav ajakiri "Vaatleja", sündmuste kalender, Eestiga seotud pilte avaldav "Astronoomiapildi" rubriik ning astronoomiahuviliste infovahetuseks mõeldud foorum.

1.8 Tänuavaldused

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

2 Summary

2.1 Research projects and grants

2.1.1 Target financed projects

In 2009, research in the framework of three target financed projects was continued. Due to difficult economic conditions a negative state budget was adopted in the middle of the year, decreating the main research expenses by 4%. The final amounts were as follows:

- Dark Energy, Dark Matter, and the formation of structure in the Universe (principal investigator E. Saar) – 3 571 776 kEEK,
- Observational and theoretical investigation of stars and their envelopes during advanced evolutionary phases (principal investigator T. Kipper) – 4 651 584 kEEK,
- Remote sensing of optically complex natural environments (principal investigator A. Kuusk) – 1 002 720 kEEK.

(1 kEEK = 1000 EEK = 63.9 EUR)

2.1.2 Estonian Science Foundation grants

The Estonian Science Foundation financed 13 grant projects from our Observatory:

- Grant 6810: I. Kolka – Luminous highly evolved stars in the framework of Gaia – 135 360 EEK.
- Grant 6812: M. Mõttus – Applicability of hyperspectral and multiangular remotely sensed data for estimating forest structure – 167 904 EEK.
- Grant 6813: J. Pelt – Theory and applications of dispersion spectra – 76 800 EEK.
- Grant 6814: A. Reinart – Development of the remote sensing methods according to the specific conditions of Estonian optically multicomponental waters – 239 040 EEK.
- Grant 6815: T. Nilson – Monitoring the productivity of Estonian forests by satellite remote sensing – 196 800 EEK.
- Grant 7115: A. Tamm – Evolution of disc galaxies on cosmological time scales – 55 200 EEK.
- Grant 7137: K. Eerme – Spectral composition of the ground-level solar ultraviolet radiation – 96 000 EEK.
- Grant 7146: M. Gramann – Evolution of galaxies and dark energy in the expanding Universe – 88 320 EEK.
- Grant 7691: V.-V. Pustynski – Physical processes, statistical characteristics, and evolutionary changes in binary systems with hot subdwarfs – 67 200 EEK to Tartu Observatory.

- Grant 7725: A. Kuusk – Angular distribution of forest reflectance – 288 000 EEK.
- Grant 7765: U. Haud – Visible and dark matter in galaxies – 153 600 EEK.
- Grant 8005: E. Saar – Light cones: evolution of cosmic structures – 268 800 EEK.
- V. Russak participated in the grant 7347 led by H. Ohvril from Tartu University (57 600 EEK to Tartu Observatory) and in the grant 7332 led by T. Tomson from Tallinn University of Technology.

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 two post-doc grants:

- Post-doc grant JD 107 (01.01.–31.08.2009): Abdelaziz Kallel – Modelling radiating transfer in vegetation: enhancement and validation of the adding method – 275 000 EEK.
- Post-doc grant JD 131 (01.01.–31.12.2009): M. Saal – Theoretical and cosmological aspects of generalized gravitation theories – 324 500 EEK.

2.1.3 The FP7 project EstSpacE

The European Commission 7th Framework Programme project EstSpacE (Expose the Capacity of Estonian Space Research and Technology through High Quality Partnership in Europe) was continued, with A. Reinart as the project leader (duration 01.03.2008–28.02.2011). Total financing by the EC is about 1.1 MEUR (17.206 MEEK), of which 5448.7 kEEK was delivered in 2009. Main activities of the project in 2009 will be described in relevant chapters of the present Annual Report.

2.1.4 Some other projects and contracts

- Review of declared agricultural parcels with remote sensing methods: U. Peterson – 40 000 EEK.
- NORDic network for AQUAtic REMote Sensing (NordAquaRemS): TO coordinator A. Reinart – 154 136 EEK.
- Improving Satellite Remote Sensing Products for Large Lakes, EMP 2008: A. Reinart – 323 350 kEEK.
- National programme of environmental monitoring, subprogramme "Studies on change of Estonian landscapes and remote sensing": U. Peterson – 200 000 EEK.
- Technical assistance for the validation of MERIS products for lake Vänern and coastal waters of the north-western Baltic Sea. ESA/ESRIN subproject, Stockholm University contract No. 21524: A. Reinart – 60 996 EEK.

- Space-based applications serving Europe/Integration, harmonization, utilization and delivery of GMES data. Enterprise Estonia 2008–2009: U. Peterson – 139 830 EEK.
- Using satellite data for assessment and prognosis of algae blooms. Swedish Meteorological and Hydrological Institute, contract No. 2007/2213/43, 2009–2010: A. Reinart – 139 960 EEK.
- Development of (Estonian) space terminology: U. Veismann – 10 000 EEK.

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

Our long-time head book-keeper Liidia Meier retired on April 30, 2009. Külli Kärner is working as a new head book-keeper from May 1, 2009.

Economic crisis forced to decrease workload, and respectively salaries, of some people, but fortunately not to end the work contracts. Instead, we were able to employ new people, mostly thanks to the FP7 project EstSpacE.

Mart Noorma was employed as a part-time (0.3) senior research associate on May 1. From October 1 we have Aivo Reinart working as a research associate and Jan Pisek as a senior research associate. The latter is a citizen of Czech Republic who arrived to our Observatory from Toronto. From November 1, Gert Hütsi is back in our Observatory, also thanks to the EstSpacE project.

Ingrid Enkvist is working as a part-time (0.5) engineer in the department of cosmology from May 1. Senior research associate Matti Mõttus wished to stop his contract on July 1, he is working in Finland at present. Post-doc associate Abdelaziz Kallel terminated his contract on August 31, in advance of the deadline, as he was elected a professor in his homeland Tunisia. We have a new Estonian Science Foundation post-doc associate Erko Jakobson from January 1, 2010.

On April 6, 2009 the working contract of the director Laurits Leedjärv ended. As nobody submitted an application for the post of the director in the public contest, the Scientific Council declared the contest failed, and asked the Ministry of Education and Research to extend the contract with Laurits Leedjärv for one more year.

Research associate of the group of theoretical astrophysics Anna Aret successfully defended the Ph.D. thesis in the University of Tartu on June 5, 2009.

As a result of all the changes, the number of people employed by the Tartu Observatory was 78 on January 1, 2010. Of them, 48 are on the position of researchers and 9 on that of research engineers.

2.3 Awards

The International Centre for Relativistic Astrophysics (ICRA) and the associated network of research institutes (ICRANet) issue an annual Marcel Grossmann Award for outstanding contributions in theoretical physics and cosmology. In 2009, one of the awards was attributed to Professor Jaan Einasto for pioneering contributions in the discovery of dark matter and cosmic web and fostering research in the historical Tartu Observatory. Other recipients were Christine Jones for her contributions to the X-ray studies of galaxies and clusters, and Michael Kramer for fundamental contributions to pulsar astrophysics. The Awards were delivered at the opening ceremony of the 12th Marcel Grossmann meeting on July 12, 2009 in Paris, UNESCO headquarters.

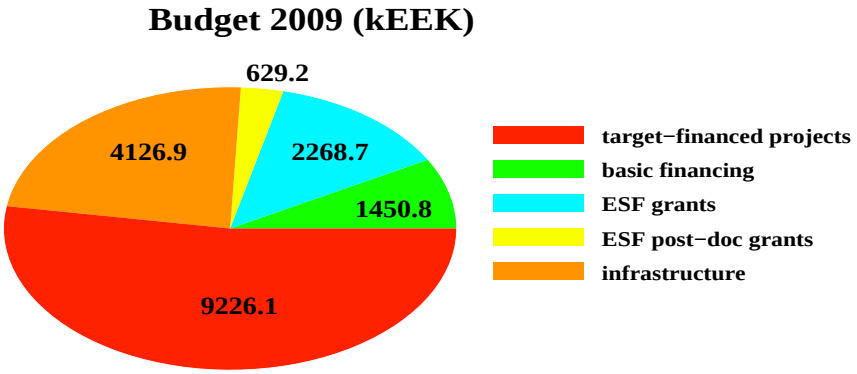
Jaan Einasto celebrated 80th birthday in 2009. On this occasion, the name Einasto was attributed to the minor planet 11577 by the International Astronomical Union. The exhibition "Per aspera ad astra" was opened in the University of Tartu Library on the same occasion.

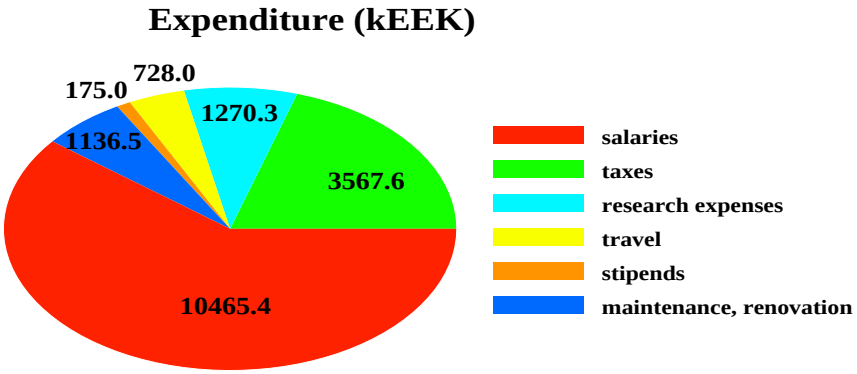
Estonian Academy of Sciences, Ministry of Education and Research and the Archimedes Foundation organize a yearly competition on popularization of science. In 2009, one of the first prizes was awarded to Uno Veismann for popular scientific articles published in 2000–2008.

The Heino Eelsalu fellowship foundation at the Estonian National Culture Foundation awarded the fellowship for 2009 to Tõnu Tuvikene from the Astronomy Club of the Old Tartu Observatory.

2.4 Budget

The total amount allocated from the state budget directly to the Observatory was 17 748.2 kEEK and it was divided as follows:





In addition, about 7024 kEEK from contracts with several organizations were allocated to the Observatory.

The mean monthly salary of researchers (including those working in the EstSpacE project) was approximately 18 944 EEK (1210 EUR) by the end of 2009.

2.5 Instruments and facilities

Several scientific instruments were purchased in 2008 through the EstSpacE project. Some of them were tested, calibrated or put into operation in 2009, like for example:

- Field portable spectroradiometer system SVC HR-1024 (Spectra Vista Corporation), 350–2500 nm, 1024 spectral bands.
- Spectrometric system for measurements of solar ultraviolet radiation, based on the Bentham DMc150F-U double monochromator. The monochromator is installed in a thermostated Envirobox chamber at the Tartu-Tõravere Meteorological Station of EMHI.
- Photometer for a large-format astronomical CCD-camera iKon-L (Andor Technologies) was ordered from the Protolab (Tartu) mechanical enterprise. New photometer allows to use large photometric filters, giving full field of view free of vignetting. Useful imaging area will grow (compared to current setup) about 6 times, giving noticeably better efficiency to the 0.6 m telescope.

The automatic guiding system of the 1.5 m telescope has been updated with a new CCD camera ST-402ME.

Astronomical observations were continued as usually, but weather conditions were extremely bad during most of the year 2009. The 1.5 m telescope was used for spectroscopic observations during 32 nights, and the 0.6 m telescope for photometric observations during 2 nights, only.

2.6 Scientific Council

Tartu Observatory has a Scientific Council consisting of 13 members. There were no changes in the membership of the Council during 2009. Director Laurits Leedjärv acts as a chairman of the Council, and senior research associate Tõnu Viik as a vice-chairman. There are two members from outside the Observatory, appointed by the director: Academician Ene Ergma, speaker of the Parliament of Estonia, and Prof. Rein Rõõm from Tartu University. Associate professor Peeter Tenjes has been appointed by the Ministry of Education and Research.

The Scientific Council held 10 meetings in 2009. The following scientific reports were presented:

January – *A. Tamm*: Dust in the Universe.

February – *M. Mõttus*: New opportunities in the remote sensing of vegetation: hyperspectral and multiangular measurements.

March – *M. Gramann*: Galaxies and Dark Energy.

April – *Vladislav-Venjamin Pustynski*: On mass loss rate of the EHB progenitors.

June – *K. Annuk*: Single, binary and multiple hot stars.

September – *J. Laur*: Photometry of fast processes in faint observation objects.

– *L.J. Liivamägi*: A catalogue of superclusters from the main and LRG samples of SDSS DR7.

– *M. Prüssel*: Dependence of the UV spectra measured at Tõravere on cloudiness.

November – *A. Kuusk, M. Lang, J. Kuusk*: A database for testing of forest radiative transfer models.

December – *M. Einasto*: On the morphology of galactic systems.

Other activities of the Council:

- On March 23, final reports of the Estonian Science Foundation grants (grantholders A. Kuusk, E. Saar, A. Sapar, and J. Vennik) were discussed and approved. A proposal was made to the Ministry of Education and Research that Laurits Leedjärv would continue as acting director for one year.
- On April 27, U. Peterson presented for approval a final report of the monitoring contract with the Ministry of Environment.
- On May 25, senior research associate Enn Saar was proposed as a candidate to the member of the Academy of Sciences of Estonia. A discussion on renovation of the main building of the Observatory was held and administration was authorized to work on with this project.
- On September 21, the Ernst Julius Öpik fellowship was awarded to the M.Sc. student Jaan Laur and Ph.D. student Lauri Juhan Liivamägi. The Juhan Ross fellowship was awarded to the Ph.D. student Margit Prüssel (all from the University of Tartu).
- On October 12, applications for continuation of the target financed projects were approved as well as accompanied applications for smaller scientific instruments and equipment.
- On November 9, an application for a medium-cost scientific equipment was in principle agreed. It will consist of two projects: renovation of the control system of the 1.5 m telescope, and a set of standards and etalons for the laboratory of optical radiometry, both of about 2.9 MEEK.
- On December 7, the work on creation of the database by A. Kuusk, M. Lang and J. Kuusk was presented for the National Science Prize in exact sciences.

2.7 Public relations

The year 2009 was declared The International Year of Astronomy (IYA2009) by the United Nations. Senior research associate Kalju Annuk was a coordinator of the IYA2009 activities in Estonia. He participated in the IYA2009 opening ceremony in Paris, UNESCO headquarters (together with Mare Ruusalepp) and in the closing of IYA2009 in Padova. Several clubs and societies, like Ridamus, Stellaarium, AHHAA Centre etc. organized different activities in the framework of IYA2009. Lectures, interviews, public observing nights etc., arranged by the scientists from Tartu Observatory are described in Chapters 11.2 and 11.3 of the present Annual Report.

The site of the Observatory at Tõravere continued to be the destination of numerous excursions in 2009: 233 groups with more than 5100 visitors. One can now see the registered excursion groups at the Observatory's website. Traditionally, a course of astronomy for 12th grades of Nõo High School was held. Numerous popular-scientific articles by our scientists are given on the page 65, public lectures and interviews on the page 89.

Annual all-Estonian meeting of amateur astronomers was also held at Tõravere, from August 12th to 16th. It attracted about 100 participants and was devoted mainly to the topic "400 years of telescopes and 200 years of astronomical research in Estonia".

The 86th issue of the Calendar of the Observatory was published as well as already traditional Calendar of the Starry Sky.

Jaan Pelt digitized the Tartu Observatory Publications vols. 1–30 (1817–1940). More than 8000 pages of historical papers are now available in the PDF format at the Tartu Observatory Virtual Museum.

Tartu Observatory began publishing press releases and science releases on its website. Science releases are based on published refereed papers and these are meant to highlight the most important scientific results for Estonian readers.

In collaboration with the Estonian Astronomical Society Taavi Tuvikene initiated a new astronomy-related website (Astronoomia.ee – portal to the Estonian astronomy). The portal publishes astronomy news, information on

Tartu Observatory hundred years ago. Photograph from the vol. XXIV of Tartu Observatory Publications.

upcoming events, weekly astronomy pictures related to Estonia, and a discussion forum for astronomy enthusiasts.

2.8 Acknowledgements

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

- Archimedes Foundation
- ASTRONET (EC FP6 project)
- Astrophysikalisches Institut Potsdam
- Estonian Academy of Sciences
- Estonian Land Board
- Estonian Meteorological and Hydrological Institute
- Estonian Ministry of Education and Research
- Estonian Ministry of Environment
- Estonian Ministry of Finance
- Belgrade Astronomical Observatory
- Estonian Science Foundation
- Enterprise Estonia
- Eurisy
- Euro–Asian Astronomical Society
- European Astronomical Society
- European Commission

- European Space Agency
- Helsinki University
- International Astronomical Union
- Institute of Astronomy of Russian Academy of Sciences
- Institute of Physics, University of Tartu
- Invent Baltics Ltd.
- Isaac Newton Group of Telescopes
- Nordic Forest Research Co-operation Committee (SNS)
- Nordic Optical Telescope
- Observatori Astronomic, Universitat de València
- Oulu University
- Pakker Avio
- Serbian Astronomical Society
- Sternberg Astronomical Institute, Moscow
- 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

Universumi ehitust ja ajalugu saab uurida mitmeti – kas puhtalt teoreetilisi kõvera ruumi geomeetria mudeleid välja mõeldes või kasutades vaatlusandmeid. Meie kasutame mõlemat teed – uurisime 2009. aastal nii võimalikke kosmoloogilisi üldistusi (gravitatsiooni skaalar-tensor-teooriate abil) kui ka vaatlustest tulenevaid järeldusi (galaktikajaotuse suuremastaabilise struktuuri ja üksikobjektide arengu põhjal).

Skaalar-tensor-teooriad, mis on üldrelatiivsusteooria üldistuseks, ennustavad mitmesuguseid huvitavaid epohhe universumi arengus (nn superkiirendusfaasi). Vaatlused seda veel otse ei nõua, aga ka ei välista. M. Saal koos P. Kuuse ja L. Järvega TÜ Füüsika Instituudist andsid selliste mudelite üldise klassifikatsiooni ja otsisid välja kõige huvitavamad võimalused.

Enamasti põhineb vaatluste interpreteerimine siiski standardsel kosmoloogial, kuigi mõistatusi on ka siin palju. Uurisime nn barüonharmoonikuid ainejaotuse statistikas (võimsusspektris) – need on põhjustatud Universumi väga kiirest laienemisest selle algepohhil. Nende abil saame teha järeldusi Universumi väga varase nooruse kohta. Leidsime need harmoonikud nii galaktikate kui nende parvede ruumjaotusest; nende omadused lubavad teha järeldusi nii tumeenergia kui tumeaine kohta. Tumeenergia kohta saab järeldusi teha ka hinnates struktuuri arengu kiirust eri epohhidel; G. Hütsi koos kolleegidega Hiroshima Ülikoolist avaldas selle kohta uurimuse.

Tumeenergia mõjutab oluliselt ka kõige suuremate teadaolevate struktuuride – galaktikate superparvede – omadusi. Nende uurimine on olnud Tartu kosmoloogide traditsiooniline temaatika. J. Liivamägi koostas superparvede kataloogi Sloani taevaülevaate andmete põhjal ja eesotsas M. Einastoga uurisime selle kõige huvitavama piirkonna, nn Sloani Suure Seina superparvi. Kirjeldasime nende kuju (morfoloogiat), uurisime superparvede dünaamikat ja galaktilist koosseisu, gruppide ja galaktikate omadusi. Erilist tähelepanu pühendasime heledatele punastele galaktikatele (LRG).

Tumeaine määrab galaktikate, nende gruppide ja parvede omadused. Leidsime vastvalminud Sloani taevaülevaate põhjal galaktikagrupid ja parved. Uurisime nende omadusi; leidsime, et paljud neist on veel muutumas. Selgelt on näha, et rikkamad parved koosnevad mitmest allparvest ja ka parvegalaktikate kiirused parve tsentri suhtes on väga suured (juba valmis, tasakaalus parves peaksid need olema tühised). See kõik näitab, et need parved on alles hiljuti elanud üle ühinemise, kas väiksema või sama suure parvega, ja parve virialiseerumine võtab veel kaua aega. Muidugi pole ka välistatud edasised parvede ühinemised.

Et mõista kärgstruktuuri tekkimist ja arengut, arvutasime Universumi numbrilisi mudeleid ja võrdlesime neid vaatlusandmetega. Kooskõla on küll hea, aga mitte täielik.

Vaatlesime lähedasi galaktikagruppe ja galaktikaid, uurisime galaktikate arengut numbriliste mudelite põhjal. Uurisime ka külma gaasi jaotust meie Galaktikas – leitud huvitava pilveringi omadused ja teke nõuavad veel seletust.

3.1 Expansion of the universe

Observations show that the expansion of the Universe has been accelerating for the last few billion years, while a consistent description of the very early Universe suggests another rapid period of acceleration (inflation). The concordance model based on the Einstein equations of general relativity (GR) including cosmological constant Λ can accommodate the late time acceleration of the Universe, but explanations in terms of alternative theories of gravitation are also searched for. Approaching the statistics of observations by more relaxed priors suggests that the expansion of the Universe as measured by the scale factor a is not only accelerating ($\frac{\ddot{a}}{a} > 0$), but might be also about to enter into a super-accelerating phase ($\dot{H} = \frac{\ddot{a}}{a} - \frac{\dot{a}^2}{a^2} > 0$), sometimes dubbed as "crossing the phantom divide". The latter possibility can not be accommodated in the cosmological concordance model based on the Einstein equations with a cosmological constant. If one prefers to play within the traditional GR, then the onset of super-acceleration can be invoked by adding another matter component with unusual "phantom" properties. An alternative explanation would require superseding GR by a more general theory of gravitation; examples of super-accelerating dust matter solutions have been studied, for instance, in the context of $f(R)$ and scalar-tensor theories.

Scalar-tensor theories of gravitation (STG) employ a scalar field Ψ besides the usual spacetime metric tensor $g_{\mu\nu}$ to describe the gravitational interaction. Scalar field is in the role of a variable gravitational "constant", leaving the tensorial metric field and its geodesics to act as trajectories of freely falling particles as in the GR. In general, STG form a collection of theories which contain two functional degrees of freedom, a coupling function $\omega(\Psi)$ and a scalar potential $V(\Psi)$. Each distinct functional form of these two functions gives us a distinct theory of gravitation together with its field equations. It is of considerable interest to determine which members of this family of theories allow solutions (model Universes) exhibiting periods of accelerating and super-accelerating expansion without introducing any unusual matter components. The study of global properties of solutions can be greatly facilitated by applying the mathematical methods of dynamical systems and phase space. Several previous detailed studies which have considered the STG cosmology as a dynamical system have focused upon examples with specific coupling functions. The main properties of a general phase space geometry corresponding to homogeneous and isotropic cosmological models were outlined by P. Kuusk (University of Tartu), L. Järv (University of Tartu) and M. Saal. They described the phase space in the most general case: one barotropic matter component, a non-vanishing scalar field potential and arbitrary spatial geometry (flat, spherical, hyperbolic), generalizing the results of previous studies.

They investigated conditions under which accelerated and super-accelerated expansion of these cosmological models is possible in STG, and also when the solutions enter or leave the epoch of accelerated and super-accelerated expansion. In the simplest and phenomenologically most relevant case of dust matter, vanishing potential, and flat spatial geometry ($k = 0$) they gave a necessary condition on the coupling function $\omega(\Psi)$ that must be satisfied for acceleration and super-acceleration to be possible at all. These conditions were also illustrated by an example of a particular case where some solutions undergo a phase of super-acceleration while some solutions do not. The paper on the topic has been submitted.

3.2 Large scale structure of the universe

In 2009 we tried to better understand the large-scale structure of the Universe and to study the basic features and evolution of the Universe.

3.2.1 Testing the inflationary paradigm

In order to test the inflationary paradigm (the initial extremely fast expansion of the Universe) we studied observational traces of baryonic oscillations, predicted by inflation theories.

G. Hütsi discovered the traces of baryonic acoustic oscillations in the power spectrum of the galaxy distribution, using the catalogue of distant galaxy clusters of the Sloan Digital Sky Survey (SDSS). The paper has been accepted by "Monthly Notices of the Royal Astronomical Society".

E. Saar, together with I. Suhhonenko and colleagues from the Valencia and Tuorla observatories demonstrated that photometric redshifts can be used to restore the matter correlation functions of deep lightcones. The paper has been published in "Monthly Notices of the Royal Astronomical Society".

G. Hütsi, together with colleagues from the Hiroshima University, studied the damping of the baryonic acoustic oscillations, and estimated the structure growth rate. One paper has been published in "Physical Review", another submitted.

Traces of baryonic oscillations can also be sought in the correlation function of galaxies. E. Saar and E. Tempel, together with colleagues from Valencia, found these in the final release of the Sloan Digital Sky Survey large red galaxy data, and studied their properties. E. Saar also solved the problem of bootstrap estimation of correlation function errors. The paper was published in "Astrophysical Journal Letters".

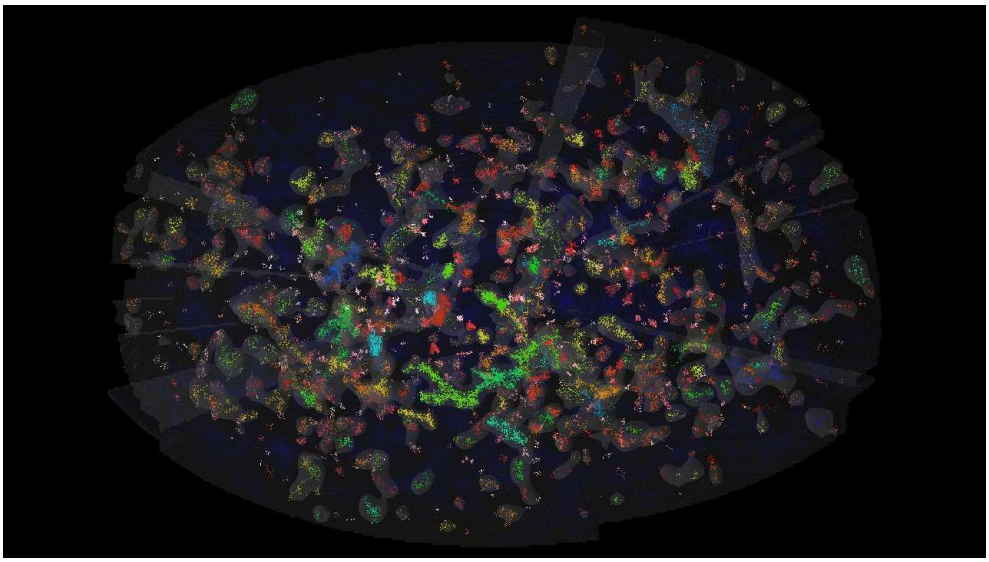


Figure 3.1: Galaxy superclusters in the Sloan Digital Sky Survey region. Colours are chosen to help to discriminate between neighbouring superclusters. Figure by J. Liivamägi. Galaktikate superparved Sloani digitaalse taevaülevaate vaatlusalas. Värvid on valitud nii, et naaberparved paremini eristuksid.

3.2.2 Dark energy and the large-scale structure

Dark energy determines the evolution of the large-scale structure; comparing theory with observations, we can set limits on dark energy. G. Hütsi, together with colleagues from the Hiroshima University, estimated the structure growth rate from the velocity distortions of the SDSS; the paper was published in "Progress of Theoretical Physics".

Dark energy influences also the formation and evolution of the largest elements of structure – galaxy superclusters and giant voids. Observational study of superclusters is the topic of the PhD thesis of J. Liivamägi. M. Einasto, J. Einasto, E. Tago and E. Saar collaborated with him in this problem. Comparing the properties of the observed superclusters with theory and numerical models allows us to check the dynamics of structure on large scales; the paper on the SDSS superclusters will be finished soon.

E. Saar, together with his colleagues from the Tuorla Observatory and the Institute of Astrophysics of Canaries tested the chances to discover the warm supercluster gas in the future ESA Planck mission data. There is a serious discrepancy between the total amount of baryons inferred from the cosmic microwave background data and that observed directly; these baryons are supposed to hide in superclusters of galaxies. The Planck mission data can reveal the presence of baryons by the Sunyaev-Zeldovich effect; we are also

studying the possibility to find the traces of baryons in the soft X-ray spectrum.

Together with R. Stoica (University of Lille) and V. Martínez (Valencia University Observatory), E. Saar developed an algorithm for searching for galaxy filaments in redshift surveys, found the filaments for the 2dFGRS North, and compared these with model filaments. The paper has been accepted by "Astronomy and Astrophysics".

As already said, limits on dark energy can be set by comparing the observed large-scale structure and its models. J. Einasto, together with I. Suhhonenko, E. Saar, E. Tempel and J. Liivamägi calculated numerical models for the formation of galaxy systems. Together with V. Müller (Potsdam) we have started to analyse the models. We have studied the influence of large-scale waves on the filament network, on the richness of superclusters and voids, and on the properties of voids. The first paper on this topic will be finished soon.

M. Einasto and her colleagues from Tartu, Tuorla and Valencia carried out a cycle of studies of a relatively nearby, but very large supercluster complex, the "Sloan Great Wall" (SGW), seen in the Sloan Digital Sky Survey data. Morphological analysis shows that the richest supercluster in the SGW, the supercluster Scl126 resembles a rich multibranching filament. Among other observed and simulated superclusters this is the only supercluster with such a morphology. Present-day numerical simulations have not been able to produce a supercluster like the supercluster Scl126. Another very rich supercluster in the SGW – the supercluster Scl111 (the Virgo-Coma supercluster) resembles a multispider (a system where individual high density cores are connected by a lower density filaments of galaxies). The morphology of this supercluster resembles a morphology of several simulated superclusters we have studied earlier.

The study of the morphology of galaxy populations shows that the clumpiness of red galaxies in superclusters is larger than the clumpiness of blue galaxies. At intermediate density levels the systems of blue galaxies may have tunnels in them. The clumpiness of bright red galaxies is similar to that of all red galaxies in superclusters. The differences between the morphology of individual galaxy populations in the supercluster Scl126 are smaller than those in the supercluster Scl111.

The differences between the morphology and individual galaxy populations between the richest superclusters in the SGW shows that these superclusters may have different formation and evolution. An example, comparing two superclusters, is shown in the Figure 1.2. The paper on the morphology of the Sloan Great Wall has been submitted to "Astrophysical Journal".

Special attention was given to bright red galaxies (BRGs). These galaxies are nearby LRGs, luminous red galaxies. The spatial distribution of these

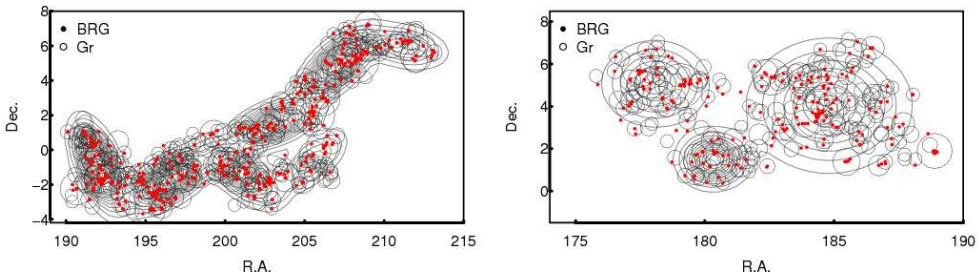


Figure 3.2: Two superclusters in the Sloan Great Wall (left panel – Scl126, right panel – Scl111). We show the projected density contours, the bright red galaxies (BRG, filled circles), and galaxy groups (open circles, scaled by the group richness). Figure by M. Einasto. Kaks superparve (vasakul Scl126, paremal Scl111) Sloani Suurest Seinast. Näidatud on tiheduskontuurid, heledad punased galaktikad (tumedad punktid) ja galaktikate rühmad (tühjad ringid, mille suurus näitab rühma rikkust).

galaxies can be compared with that of the normal galaxies in the Sloan Great Wall, but further out, large red galaxies are the only supercluster members seen. M. Einasto and her collaborators studied their group membership, luminosity, colours and morphological type, and compared their properties with the properties of those main galaxies in groups which do not belong to BRGs.

They showed that although it is generally believed that BRGs are the main galaxies in groups and of early type, actually a considerable fraction of BRGs are satellite galaxies in groups, and there are also isolated BRGs, which do not belong to any group. We suppose that these isolated galaxies are actually the main galaxies of such groups in which other group members are not observed due to the survey magnitude limit.

The peculiar velocities of BRGs in groups are large, suggesting that groups are not virialized. In the SGW the peculiar velocities of BRGs in groups are larger than those in the surrounding field. Those main galaxies in groups, which are not BRGs, are fainter, there are relatively more blue galaxies among them, and they are found mainly in poor groups.

Using the Sloan Visual Database, morphological types of about 1500 galaxies were determined. Analysis showed that about 1/3 of the BRGs are spirals; it shows that the morphological types and colours of galaxies are not well correlated. The scatter of colours of red elliptical BRGs in colour-magnitude diagrams is about two times smaller than the scatter of colours of red spiral BRGs, showing that elliptical BRGs form a more homogeneous population than spiral BRGs.

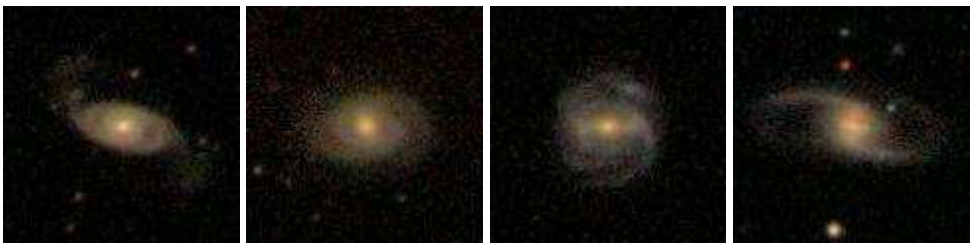


Figure 3.3: Images of four bright red galaxies from the Sloan Great Wall. Figure by M. Einasto. Neli heledat punast galaktikat Sloani Suurest Seinast.

M. Einasto and her colleagues also studied the properties of groups of galaxies in the SGW, using the catalogue of groups in the SDSS compiled by E. Tago. They showed that groups in the SGW have larger luminosities and velocity dispersions than groups in the field. Peculiar velocities of the main galaxies in the groups are large, suggesting that the evolution of groups of galaxies in the SGW and in the field have been different. Groups in the SGW are dynamically more evolved than groups in the field.

The study of the richest groups (clusters) of galaxies in the SGW shows that groups contain multiple components and are not virialized yet. About 1/3 of red galaxies in groups are spirals, red spiral galaxies are located both in the central cores of groups as well as in the outskirts. Earlier it was thought that there are only a few red spirals and they are located in the outskirts of groups being only lately merged into groups.

3.2.3 Dark matter

G. Hütsi, together with A. Hektor and M. Raidal (Institute for Chemical and Biological Physics, Tallinn), found strong observational limits on the properties of leptonically annihilating dark matter (particle mass and the annihilation cross-section). This type of dark matter is one of the most attractive possibility to explain the unexpectedly large flow of energetic positrons from the Galactic centre direction. The paper was published in "Astronomy and Astrophysics" and was chosen as the best of the issue by the editors.

Together with colleagues from Guanajato University, Mexico, E. Tago studied the relative velocities of the main galaxies of rich galaxy clusters. They found that these velocities are in many cases too large, and that the standard dark matter picture needs updating. The paper has been published in "Astronomical Journal".

G. Hütsi, together with O. Lahav (University College London), studied the cross power spectrum of galaxy clusters and galaxies in the halo model. They found that the cross-correlation carries additional information and can

be used to better estimate both the cosmological parameters and the parameters of the halo model.

J. Einasto was asked to write a survey of the discovery of dark matter for the international web-based science encyclopedia ("Encyclopedia of Life Support Systems").

3.3 Galaxies, their groups and clusters

Dark matter influences directly the dynamics of clusters and groups of galaxies. E. Tago compiled several catalogues of galaxy groups and clusters, based on the final version of the Sloan Digital Sky Survey. As the survey is finished, the main group catalogue is also final; it includes 78,800 groups up to the distance of about 900 Mpc and covers a quarter of the sky. The paper has been submitted to "Astronomy and Astrophysics".

E. Tempel, T. Sepp and M. Gramann in collaboration with P. Heinämäki and P. Nurmi (Tuorla Observatory, Finland) studied the properties of galaxy groups in the Sloan Digital Sky Survey and compared them to groups found in numerical simulations. They compared the group richness, virial radius, maximum separation and velocity dispersion and found a good agreement between the numerical model catalogues and observations. However, they also found several differences; the relation between dark matter halos and galaxy groups is more complicated than assumed usually and needs further investigation. As a first step, they started to examine in detail the luminosity functions of galaxies in numerical simulations and in observations.

E. Tempel, together with J. Einasto, E. Saar, M. Einasto and E. Tago determined the luminosity function for the 2dFGRS galaxy survey. They demonstrated that the galaxy luminosity function has a strong dependence on the galaxy environment. The paper has been published in "Astronomy and Astrophysics". The same group determined also the galaxy luminosity function of the final version (DR7) of the Sloan Digital Sky Survey. This paper is close to completion.

In a nearby region of the Sloan Digital Sky Survey we can compare the locations and physical properties of galaxies and quasars. At the present epoch, quasars tend to avoid galaxies. This study was carried out together with our colleagues from Tuorla Observatory, and it was published in "Astronomy and Astrophysics".

E. Saar, together with his colleagues from Tuorla, studied isolated elliptical galaxies. We compared observational data with numerical galaxy formation models (merger trees), found three possible formation scenarios, and predicted a yet unobserved population of faint blue ellipticals. The paper has been accepted by "Monthly Notices of the Royal Astronomical Society".

E. Tempel, A. Tamm and P. Tenjes studied the properties of cosmic dust in the local galaxy Andromeda (M31). A careful analysis of dust effects enabled them to reconstruct the actual intrinsic structure and luminosity of the galaxy.

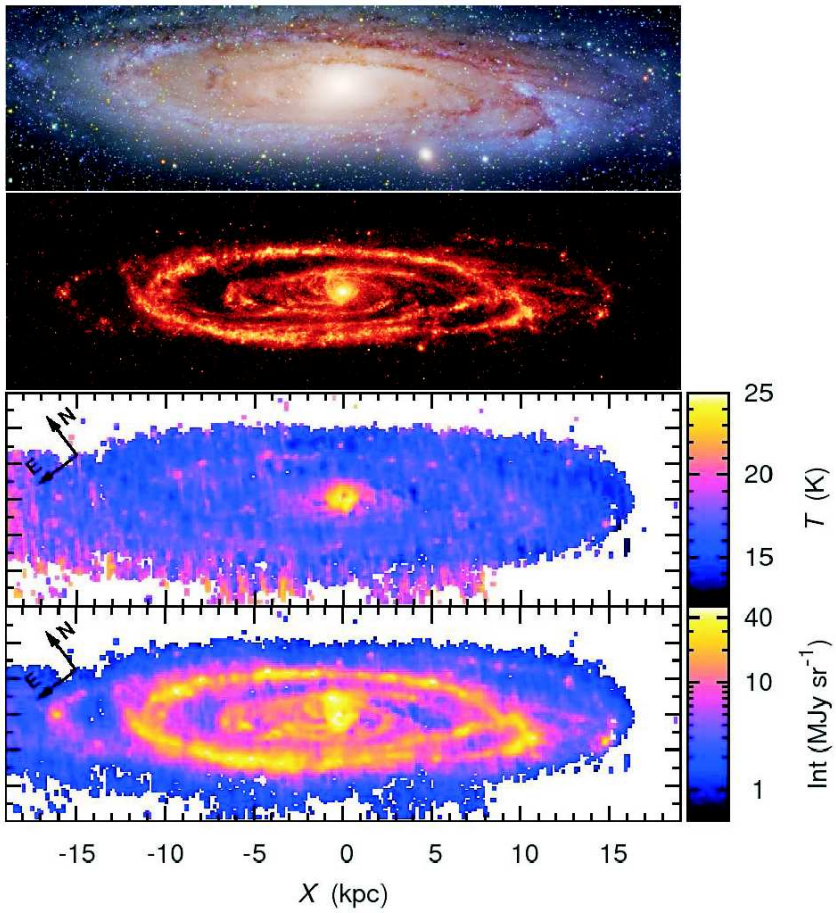


Figure 3.4: From top to bottom: optical image, far-infrared image, the cold dust temperature map and the cold dust density map of the Andromeda galaxy. Ülevalt alla: Andromeeda galaktika optilistel lainepikkustel, infrapunases kiirguses, külma tolmu temperatuuri ja tiheduse jaotus.

It is well known how drastically cosmic dust affects observations of both Galactic and extragalactic objects. Because absorption is stronger at shorter wavelengths, stars and galaxies appear redder than they actually are, while the uneven distribution of dust gives us a distorted view of the structure of extended objects. Moreover, because of dust, most of Galactic and extra-

galactic objects remain totally hidden from us at the optical and ultraviolet wavelengths. Despite the importance of dust absorption, it is still ignored in many studies because it is difficult to estimate correctly.

In this study, interstellar dust inside a luminous nearby galaxy Andromeda (M31) was analysed. Dust properties and absorption effects were found using the law of conservation of energy. While dust grains absorb ultraviolet and optical photons, their temperature increases, leading to a higher level of thermal radiation. To trace the thermal radiation, far-infrared maps of M31 were used, as measured by the Spitzer Space Telescope at 24, 70 and 160 microns. The measured spectral energy distribution was approximated by the Planck law for the black-body radiation along each line-of-sight; this gave the temperature and column density of dust at each location.

Two major dust components with different temperatures were found. A warmer component with the temperature around 56–60 K was found at the centre of the galaxy and along the spiral arms, connected with star-forming regions in the galaxy. The colder component (15–25 K) is more diffuse and about 1000 times more massive, being the dominant absorber of stellar light.

Using the derived dust distribution, optical observations of the galaxy were corrected for absorption effects and the actual structure and luminosity of the galaxy was restored. It was found that about 25% of the light emitted by the stars of the Andromeda galaxy is absorbed by its own dust. Contrary to the previous picture, the dominant component of the galaxy, the central bulge, turns out not to be oblate but rather spherical or even slightly prolate.

The results of this work have been published in "Astronomy and Astrophysics" and have been presented at several international meetings. The methodology developed for the study can be and will be applied to other galaxies, enabling to restore their intrinsic properties.

3.3.1 Nearby groups of galaxies

J. Vennik continued his studies of a sample of reasonably well isolated groups of galaxies, which are located in the outskirts of the Virgo supercluster. The newly selected dwarf member candidates of the groups have been observed spectroscopically with the Hobby-Eberly Telescope, in cooperation with U. Hopp (Munich Observatory). By now, about 30 new long-slit spectra have been obtained towards five groups. New redshifts allowed them to determine the success rate of the morphological selection, about 60%.

The impact of the group environment on the structure and star-forming properties of galaxies was investigated for galaxies inside and around three loose groups. J. Vennik found that the characteristics of the recent and current star formation history (e.g. the 4000 Å break and the width of the Hα emission-line, respectively) correlate with the local number density of gala

xies. Since the star formation activity has been found to decline relatively slowly with increasing density, it implies that gas-supply driven processes could possibly be the dominant factor in quenching of star formation in the group environment.

The morphology and stellar content of peculiar elliptical and lenticular galaxies, which are located in the dense core of the NGC 6962 group (at the redshift $z = 0.0135$), were analysed using the SDSS Stripe 82 co-added deep frames and spectral data. Local departures from the generally smooth surface brightness distribution of early-type galaxies and the occurence of nuclear disks and/or rings on their Laplacian-filtered images, could be indicative of past interactions, possibly of minor mergers.

Two papers have been submitted on these topics.

3.3.2 Our Galaxy

When studying the structure of the Galaxy, exact statistics of stellar surveys – stellar classification – is very important. This is the subject of study of V. Malyuto; he proposed, together with colleagues from the Odessa University, a new method for estimating the colour indices of supergiants. This will allow precision mapping of the absorption by Galactic dust. V. Malyuto, together with colleagues from the Rostov University (Russia) started also a project for homogenization of existing stellar catalogues.

Apart from the stars, the Galaxy contains gas, both in hot star formation regions, and cold hydrogen far from them. Mapping the gas distribution, using radio data, is a difficult problem. U. Haud continued the analysis of the results of the Gaussian decomposition of "The Leiden/Argentine/Bonn (LAB) Survey of Galactic H I". In 2009 the main attention was focused on identification of the "clouds" of similar Gaussians in the 5-dimensional parameter space (two sky coordinates, velocity, width and height of the Gaussians). He created a new algorithm for that, based on the single-link hierarchical clustering procedure with some modifications (a large number of components and the requirement of a single Gaussian per cloud from every observed profile). To some extent it also takes into account the similarity of global properties of the merging clouds. U. Haud tested the algorithm by searching the clouds of the narrowest H I 21-cm line components, as the proposed measure for a similarity of Gaussians is most critical for such cold clouds.

The program easily detected the coldest known H I clouds and demonstrated that actually they form a part of a long narrow ribbon of cold clouds, covering about 80° on the sky. U. Haud modelled these clouds as a part of a planar gas ring, deduced their spatial placement, and discussed their relation to supernova shells in the solar neighbourhood. In his model the clouds are located at the distances of about 30–70 pc from the Sun. The smaller bright-

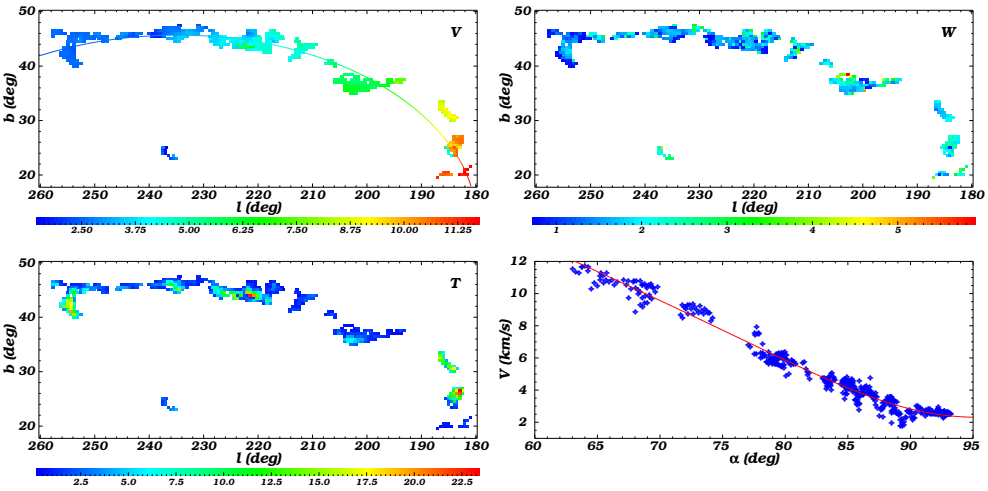


Figure 3.5: The velocities V, line-widths W and brightness temperatures T of the clouds in the region of the observable part of the ring. The coloured line in the upper left panel represents the sky positions and the velocities of the model ring. A more detailed comparison of the observed LSR velocities of the ring clouds (blue diamonds) with the model velocities (red line) is given in the lower right panel of the figure. Here the abscissa is a polar angle in the ring plane. Figure by U. Haud. Ringi nähtava osa pilvede kiirused V, joonte laiused W ja heledustemperatuurid T. Ülemisel vasakpoolsel osajoonisel on värvilise joonega kujutatud mudelringi asukoht ja kiirused. Ringi pilvede vaadeldud kiiruste (sinised rombid) täpsem võrdlus mudeliga (punane joon) on toodud alumisel parempoolsel osajoonisel, kus argumendiks on punktide polaarnurk mudelringi tasandis.

ness temperatures of the ring clouds at the lower galactic longitude tip of the stream is explained by increasing distances between the Sun and the ring clouds in this region, and the abrupt end of the stream at the higher longitude part is caused by the intersection of the ring with the S2 supernova shell from the model by Wolleben (2007).

Some other narrow line H I structures were also briefly described. The ring clouds seem to be rather unique. Most likely they are the coldest clouds, which may be found in the LAB Survey. Slightly warmer clouds (clouds with slightly wider 21-cm emission lines) may be related to local gas structures inside or near the Local Bubble. Usually such a gas is studied by its absorption lines, which allow estimation of physical conditions in the local gas. The H I 21-cm emission line is less useful in this respect, but it is useful for discovering interesting features of the gas distribution in the local neighbourhood.

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

Tähtede mitmekesine maailm kujundab olulisel määral Universumi keemilist evolutsiooni. Kosmoloogiliste uuringute kõrval jätkus meil traditsiooniliselt ka tähefüüsika.

Jahedatest tähtedest jätkati post-AGB ja vesinikuvaeste tähtede spektroskoopilist uurimist. Seekord oli vaatluse all oletatav post-AGB täht HD 159378, mida peeti ka väga pikaperioodiliseks (70–80 päeva) tsefeiidiks. Spektrite analüüsist selgus, et täht ei ole ei post-AGB evolutsioonifaasis ega ka tsefeiid, vaid väga noor ($< 2 \cdot 10^7$ aastat) kollane pulseeruv ülihiid.

T. Nugis, K. Annuk ja A. Niedzielski ning K. Czart Toruńi Ülikoolist (Poola) jätkasid WN tähtede lähis-IP spektripiirkonna analüüsi. T. Nugis jätkas ka kuumade tähtede optiliselt paksude tuulte modelleerimist.

Viimaste aastate tähespektrite vaatlused suurte maapealsete ja kosmoseteleskoopidega, mis on varustatud moodsate kõrge spektraallahutusega ja signaal-müra suhtega spektrograafidega, on püstitanud ka kõrged nõuded teoreetilisele täheatmosfääri modelleerimisele ja tähespektrite arvutamisele. A. Sapar, A. Aret, R. Poolamäe ja L. Sapar on võtnud eesmärgiks oluliselt parandada füüsikalisi lähteandmeid, vastavate uute algoritmide väljatöötamist ja tarkvara moderniseerimist, rakendades laialdaselt paralleliseerimismeetodit kohaliku mitmetuumaliste personaalarvutite võrgu ning Python arvutiskripti baasil.

Jätkus tuulevaiksetes elavhõbeda-mangaani tähtede atmosfäärides toimuva keemiliste elementide ja nende isotoopide difusioonilise separeerumise tarkvara täiustamine. Õnnestus selgitada mõningaid uusi isotoopide separeerumise omapärasid ja arvutada, kuidas turbulents täheatmosfääris mõjutab elavhõbeda isotoopide difusiooni.

V.-V. Pustynski uuris ekstremaalse horisontaalharu (EHB) tähtede tõenäoste eellaste lähteparameetreid välja selgitamaks, missugustes parameetrite väärtuste piirides on võimalik EHB objekti moodustumine lähiskaksiksüsteemis. On leitud, et massisuhte M_1/M_2 suuremad algväärtused soodustavad EHB tähtede teket, samas suured doonori algmassid M_1 takistavad seda. Akretsiooni efektiivsus (akretsioon 20% – 30% massist) ja suuremad korotatsiooniraadiused soodustavad EHB tähtede moodustumist, kuid orbitaalevolutsiooni ajaskaala ei saa olla liiga lühike, sest muidu doonortäht ei jõua kaotada piisavalt massi.

Jätkusid paljude kaksiktähtede spektroskoopilised vaatlused. Uuriti võimalust liigitada Be-tähte sisaldav kaksiktäht AX Mon W Ser tüüpi tähtede pikaperioodiliseks juhtumiks.

T. Eenmäe jätkas näivalt aeglaselt pöörlevate B-spektriklassi tähtede spektrite analüüsi. Veelgi kasvanud kvaliteetsete vaatlusandmete hulk võimaldab suurema täpsusega uurida tähtede kiire pöörlemise mõju vaadeldud spektritele ning hinnata võimalikku meetodit tähtede tegelike pöörlemiskiiruste ja -telgede asendi leidmiseks.

WR tähtede eristamiseks kosmoseteleskoobi Gaia ulatuslikust andmebaasist uuriti nn fotomeetriliste pseudoindeksite võimalusi. Üliõpilane Jürgen Jänes kaitses lähedasel teemal ka bakalaureusetöö "Emissioonijoontega tähtede eristamine kosmoseteleskoobi Gaia objektide hulgas".

Kaksiktähe V838 Mon fotomeetriliste ja spektroskoopiliste aegridade analüüs on pooleli.

I. Vurm ja A. Beloborodov uurisid gammasähvatuste spektrite moodustumisel olulisi kiirguslikke protsesse. Vaadeldav kiirgus nimetatud ülivõimsates, kuid lühiealistes objektides arvatakse pärinevat ultrarelativistlikust väljavoolust, mis kaasneb kompaktse objekti (musta augu) sünniga.

T. Viik täiustas programmipaketti HOMOGEN, mille abil saab leida kiirgusvälja kõiki parameetreid tasaparalleelses homogeenses optiliselt poollõpmatus või lõplikus atmosfääris, mis hajutab kiirgust isotroopselt või mõnede lihtsamate indikatrisside järgi.

4.1 Late-type stars

The studies of post-AGB and hydrogen-deficient stars were continued by T. Kipper. In 2009 a suspected very long-period (70–80 days) Cepheid HD 159378 was analysed using the spectra from the ELODIE archive. The star was listed in Simbad database as a post-AGB supergiant of spectral type G2Ia. It is a possible member of the open cluster Trumpler 27. This was the first analysis of the spectra of HD 159378. We estimated $T_{\rm eff} = 7500$ K and $\log g = 1.0$ or even 0.5. This is by 2000 K hotter than previously considered and corresponds to the spectral type F0Ia.

With this high temperature the star is located in the HR diagram evidently blueward of the Cepheid instability strip and is much more luminous than the post-AGB stars. The high luminosity is supported by the large reddening derived from diffuse interstellar bands.

The derived low abundance of heavy elements also shows that the star is not in a post-AGB phase of evolution. We also collected all available photometric measurements of HD 159378. A possible periodicity in the compiled photometric data was verified by J. Pelt. He found a period of 90.6 days. The light curve does not resemble those of classical Cepheids in which the rising part is about two times shorter than the declining part (Fig. 4.1). We concluded that HD 159378 is a young ($< 2 \cdot 10^7$ yr) yellow supergiant which metallicity is in agreement with its position in the Galactic disk. Now it is listed in Simbad database as a semi-regular pulsating star.

4.2 Hot luminous stars

T. Nugis in collaboration with K. Annuk and A. Niedzielski and K. Czart from Toruń University (Poland) continued the study of the near IR spectral range of WN stars based on the observations described in the paper of Nugis et al. (2008).

T. Nugis continued the modelling of optically thick winds. He studied the regulation mechanisms which determine the matter outflow regimes in different types of massive stars. The results of these studies are in preparation for publication.

T. Nugis started investigations for finding the contribution of the non-selective component in interstellar (IS) and circumstellar (CS) extinction. The total extinction can be described as the sum $C_1(\lambda) + C_2$, where $C_1(\lambda)$ is the component which depends on the wavelength and C_2 is the component which is not depending on the wavelength. The component $C_1(\lambda)$ is quite well known from the observations, but the contribution of C_2 is not well known. For the correct determination of the contribution of C_2 it is needed to know correctly the distances of the stars with well determined stellar para-

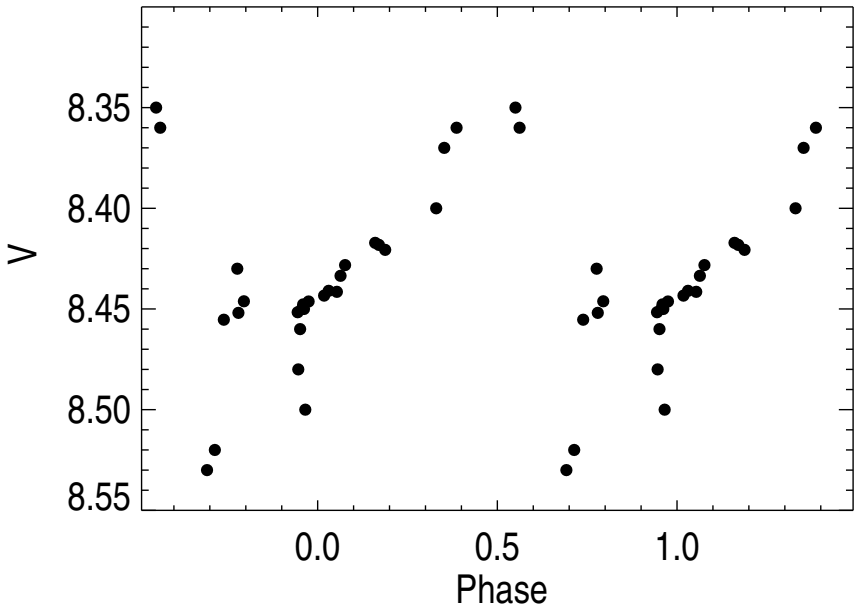


Figure 4.1: The phase diagram of the variability of HD 159378 for the interval JD 2443900÷2444500 with a period of 90.6 days. HD 159378 muutlikkuse diagramm ajavahemikus JD 2443900÷2444500 perioodiga 90.6 päeva.

meters. The future measurements of the distances by the Gaia project make it possible to determine C_2 in different directions and locations in the Galaxy and maybe also in the LMC.

4.3 Physics of hot stellar atmospheres

During recent years observations of stellar spectra with large ground- and space-based telescopes, equipped with modern high-resolution and high signal-to-noise ratio CCD spectrographs, supported by the detailed processing of observational data, set high demands on the precision of stellar atmosphere modelling and computation of stellar spectra.

In order to meet this challenge, A. Sapar, A. Aret, R. Poolamäe and L. Sapar started to work on improving the accuracy of input physics and on elaborating corresponding new software algorithms to update the modelling software SMART (Fortran 90). The code has been parallelized and computations are now distributed over the local network of the multi-core personal computers using Python scripting.

Further efforts have been undertaken to expand the range of effective temperatures and surface gravities of stellar atmospheres properly modelled with the program SMART. For high-temperature stellar atmospheres the analytical formulae for radiative transfer, taking adequately into account frequency redistribution in spectral lines due to the Thompson scattering on free electrons, have been derived. Broadening of hydrogen and helium spectral line profiles due to the Stark splitting is particularly important for white dwarfs with large surface gravities. Corresponding improvements are being elaborated and applied to the code. Stability of used computation algorithms, which is essential for the modelling of stellar atmospheres of supergiant stars near the Eddington luminosity, is being improved.

Triggering of stellar wind and nature of microturbulence, which still remain unclear, are being studied since both of these phenomena modify the spectral line profiles in the emergent stellar spectrum. Also a more physical approach to the theory of convective energy transfer, necessary for cooler stars, which still lies on the rough mixing-length theory, is needed. More adequate expressions for the partition functions, which modify ionization degrees, are being computed.

Refinement of the code for modelling diffusion of chemical elements and their isotopes in the quiescent atmospheres of mercury-manganese (HgMn) stars has been continued (A. Sapar, A. Aret, R. Poolamäe and L. Sapar). The observed overabundances of heavy metals reaching 6 dex in atmospheres of chemically peculiar stars are formed due to uplift pressure on the line-rich chemical elements generated by radiative force throughout the stellar envelope. Radiative-driven diffusion in stellar interiors pushes heavy elements to the outer envelope during stellar evolution. This process does not affect the isotopic mixture of the chemical elements and thus matter entering the atmosphere from beneath has initial (terrestrial) isotope composition. In the atmosphere light-induced drift (LID) switches on, effectively separating isotopes and generating anomalous isotope mixtures. Observed abundances form in the result of complex interplay between gravity, radiative force, LID, stellar wind and microturbulence.

Equilibrium concentration profiles of mercury isotopes throughout the atmosphere in the presence of microturbulence have been iteratively computed for several model atmospheres. Presence of microturbulence in the atmosphere drastically slows down the diffusion and reduces resulting abundance gradients. However, main regularities of the separation remain the same: the heaviest isotope is strongly supported in the atmosphere while lighter isotopes sink to inner layers of the envelope (Fig. 4.2).

Compilation of input data to carry out similar computations for Ca, taking into account hyperfine and isotopic splitting of spectral lines, has been undertaken.

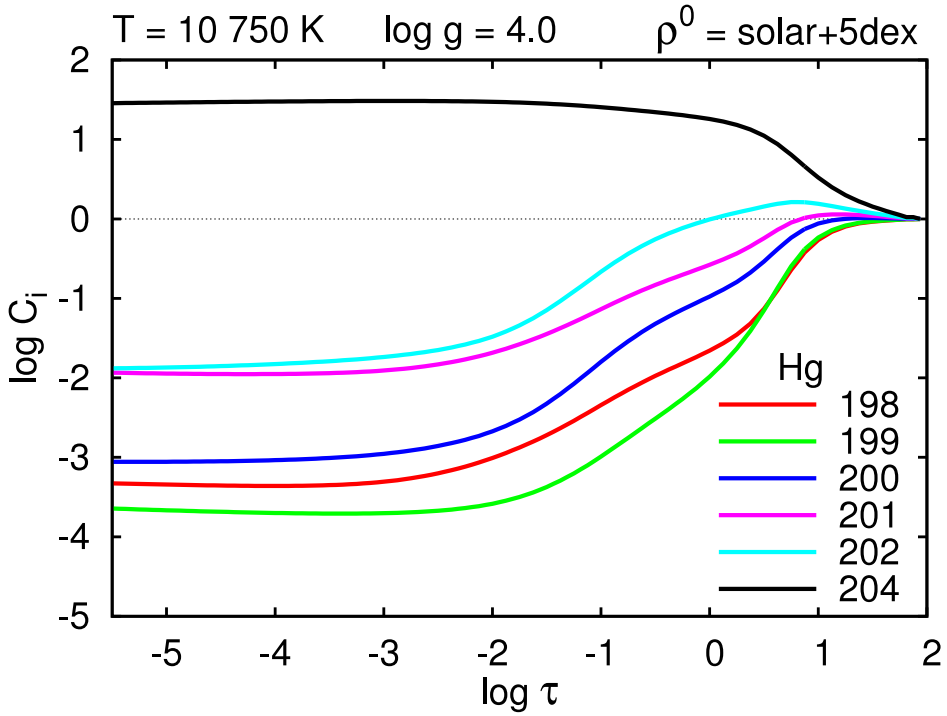


Figure 4.2: Equilibrium concentrations of mercury isotopes i relative to their initial values ρ_i^0 in a model atmosphere with microturbulence are given for optical depths $\tau = 10^{-5.5} \ldots 10^2$. Microturbulent diffusion coefficient is assumed to be 50 times the atomic diffusion coefficient. Elavhõbeda isotoopide kontsentratsioonid algkontsentratsioonide ρ_i^0 suhtes on esitatud funktsioonina optilisest sügavusest τ. Mikroturbulentse difusiooni koefitsient on võetud atomaardifusiooni koefitsiendist 50 korda suuremaks.

4.4 Eclipsing close binaries

V.-V. Pustynski continued research of extreme horizontal branch (EHB) binary progenitors. EHB objects are compact underluminous subdwarf B stars with high surface temperatures and gravities ($T > 25\,000$ K, $\log g > 5$), their typical masses are about $0.5\,M_\odot$; they burn helium and possess very thin ($M < 0.02\,M_\odot$) hydrogen envelopes. For decades UV excess in continuum spectra of globular clusters and elliptical galaxies has been attributed to presence of these objects. However, the role of EHBs is still uncertain, so their birth rate needs to be determined. Various scenarios of their formation have been proposed. Recently it has been discovered that many known EHBs are companions in short-period binaries, $P \sim 10^{\mathrm{h}} - 30^{\mathrm{d}}$, their pairs being main sequence low mass stars. So it is important to clarify which role does binarity play in formation of EHB objects.

Earlier V.-V. Pustynski and I. Pustylnik elaborated a model of EHB precursor as a binary where the donor fills its Roche lobe on a certain stage of its nuclear evolution and loses mass through the 1st Lagrangian point. The system additionally loses angular momentum due to corotation at the Alfvén radius. Ranges of initial parameters of assumed EHB binary progenitors were studied in detail. Factors that favour close binary formation are smaller initial separation, larger initial mass ratio M_1/M_2, higher mass transfer rate and larger corotation radius. However, if the final donor mass in the emerging close binary is higher than characteristic masses of EHBs ($\sim 0.5\,M_\odot$), the system should be excluded from the list of potential EHB-forming binaries. So, high initial donor mass requires more intensive mass loss during phase of orbital evolution and thus limits effectively the range of parameters where formation of a close EHB is possible. Actually, if the corotation radius is small, only a narrow slit of initial separations exists for donors with masses $> 1\,M_\odot$ inside which a close EHB can be formed. With donor's mass $> 3\,M_\odot$ close EHB cannot emerge unless the corotation radius reaches several radii of the donor. Smaller masses of the primary highly broaden the range inside which a close EHB can be formed. If the initial donor's mass is $< 1\,M_\odot$, the lower limit of initial separations vanishes at all. Even in this case, absence of corotation makes probability of close EHB formation quite small unless mass transfer effectiveness is high; however, high accretion rates require specific conditions in the progenitor system (intense magnetic interaction of the components).

Another noticeable effect is that too rapid close binary formation (which occurs when corotation radius is large and the system loses angular momentum effectively) results in higher final masses of the donor. So, larger initial separations are required to allow EHB formation, compared to the case of moderate corotation radius. In other words, to form an EHB object, the system should have enough time to lose enough matter that would permit it to get inside the mass range of EHB objects.

V. Harvig in collaboration with T. Aas and M. Mars (Tallinn University of Technology) continued to observe and study variable objects V497 Cep and EM Cep in the open cluster NGC 7160. V497 Cep is ellipsoidal or eclipsing variable with the period of 1.2^{d} and the amplitude $< 0.2^{\mathrm{m}}$. EM Cep is λ Eri type variable with the period of 0.8^{d} and the amplitude $< 0.2^{\mathrm{m}}$. Their interesting peculiarity is high dispersion of the observational data. The observations have been carried out for years in Tallinn Observatory and Maidanak Observatory.

4.5 Symbiotic stars and related objects

Spectroscopic observations of symbiotic stars and related objects (CH Cyg, AG Dra, EG And, Z And, AX Mon, VV Cep) were continued in 2009 by K. Annuk and A. Puss. Due to bad weather conditions almost throughout the year, the amount of collected data remained quite modest.

Analysis of the observational data for the yellow symbiotic star AG Dra was continued by M. Burmeister and L. Leedjärv in collaboration with L. Hric and R. Gális from the Astronomical Institute of the Slovak Academy of Sciences. Statistical analysis of the extensive photometric data persistently shows two principal periods, 550 days and 355 days, which are interpreted as the orbital period of the binary system and the pulsation period of the cool giant, respectively. In principle, the same periods, though with greater uncertainties, are detectable in radial velocities and equivalent widths of the strongest emission lines of H I, He I and He II. Interplay of those two phenomena and possible role of resonances between these two periods as a trigger for the symbiotic outbursts remains to be explained in physical terms.

4.6 Peculiar stars

The investigation of photometric and spectroscopic time series on V838 Mon is in progress (I. Kolka, T. Liimets, T. Kipper, T. Tuvikene). The long duration of its brightness low state in U and B filter bands which started in the middle of 2008 suggests that the still continuing eclipse of the hot component in this binary system could be the explanation for the observed behaviour. With the successful "Fast track" photometric observing proposal (T. Liimets, I. Kolka) for the Nordic Optical Telescope on La Palma this scenario will be monitored and checked.

T. Liimets, I. Kolka, T. Tuvikene with R. Corradi (Isaac Newton Group) studied the structure and kinematics of circumstellar matter around typical representatives of outbursting stellar objects: V838 Mon, GK Per, and R Aqr. The data collected earlier were pre-reduced and new data were obtained with the Nordic Optical Telescope. Development of the method to analyse the expansion of the nova remnant GK Per was started. The list of comparison stars in the field of V838 Mon was extended towards fainter stars.

During the year 2009, both spectroscopic and photometric observations of an eclipsing star HD 292574 continued.

T. Eenmäe continued the analysis of B spectral class stars which appear to rotate very slowly. Continuously growing amount of good quality observational spectra allows to study the effects of rapid rotation on the observed spectra. Large database of spectra allows to evaluate a method to measure actual rotating speed and orientations of rotational axes of hot stars.

4.7 Gaia mission

The task to distinguish WR type stars from other emission line stars in the expected multitude of Gaia space telescope objects was solved with two different methods applied on corresponding simulated Gaia blue photometer (BP) and red photometer (RP) low resolution spectra. The first approach uses specific synthetic photometric indices (I. Kolka), and the second is based on the classification process with artificial neural networks and support vector machines (J. Jänes, I. Kolka).

4.8 Time and frequency analysis of astronomical phenomena

J. Pelt with J. Laur from the University of Tartu studied the shutter based high speed low light photometrical measurement schemes. Based on use of the single photon detectors and ultrafast optical switching, these methods are very promising and if properly implemented, will have many interesting applications in astrophysics. They tried to establish the operational limits of proposed measurement schemes. It is already clear that the well known classical Nyquist frequency limit can be beaten by a proper set up of the photometric experiment.

With N. Olspert (Playtech), M. Korpi and M. Lindborg (Helsinki), J. Pelt started to analyse the photometric light curves of the RS CVn type binary star II Peg. The results of surface imaging are compared with the results of photometric analysis. The main goal of the investigation is to look at previously claimed ”flip-flop” events in the variability patterns.

J. Pelt and A. Hirv concluded the cycle of investigations devoted to different methods of time delay and correlation lag estimation. The newly developed – nearly automatic – methods can be applied to analyse different observed data sets. Wide overview of the new results and corresponding software will be presented in the PhD dissertation of A. Hirv.

4.9 Radiative transfer

The package of software HOMOGEN for determining all the parameters of a radiation field in plane-parallel homogeneous atmospheres was upgraded by T. Viik. The atmosphere is supposed to scatter radiation isotropically or according to some simple phase functions.

I. Vurm and A. Beloborodov (Oulu) studied the radiative mechanisms responsible for prompt gamma-ray burst emission. The spectrum in these short-lived and extremely powerful objects is thought to be formed within a highly relativistic outflow associated with the birth of a compact object (i.e.

black hole). To study the spectral formation within the expanding outflow, the kinetic code developed by I. Vurm and J. Poutanen was improved for modelling radiative processes to account for adiabatic losses as well as relativistic aberration. The results have been compared to a Monte Carlo code developed by A. Beloborodov for the same problem, finding a good agreement.

5 Remote sensing of optically complex natural environments Optiliselt keerukate looduskeskkondade kaugseire

Täppisteaduste seisukohalt keerukaid looduskeskkondi leidub nii õhus, maal kui vees. Mitmekesised on ka nende uurimismeetodid: vaatlused satelliitidelt ja õhusõidukitelt, maa- ja veepealsed välitööd, laborimõõtmised ja muidugi teoreetiliste mudelite loomine.

Päikesekiirguse, eriti selle ultravioletse (UV) osa uurimisel oli oluliseks verstapostiks topeltmonokromaatoril Bentham DMc150F-U baseeruva spektromeetri ülesseadmine ja töölerakendamine. EMHI Tartu-Tõravere meteoroloogiajaamas termostateeritud kambris asuv spektromeeter registreerib päevasel ajal päikese ultravioletkiirguse spektri iga 15 minuti järel. Samal ajal jätkatakse mõõtmisi ka minispektromeetriga AvaSpec-256. UV kiirguse spektromeetrilised mõõtmised ulatuvad siiski ajas suhteliselt vähe tagasi. Paljude ülesannete puhul oleks vaja teada aastakümnete pikkusi aegridasid. K. Eerme ja teised meie UV kiirguse uurijad osalesid aastail 2004–2009 COST 726 projektis, mis rekonstrueeris erüteemse UV kiirguse mõõtmisandmed rohkem kui 50 aasta taha.

Vee kaugseire puhul oli 2009. aastal uudseks teemaks fütoplanktoni massiõitsengu määratlemine Läänemeres ja suurtes järvedes. Sinivetikate massiline õitsemine leiab Läänemeres aset igal aastal ja võib ulatuda mitmete tuhandete ruutkilomeetriteni. Ka Eesti suurtes järvedes esineb vetikate massiõitsenguid, mille kestvus ja ulatus varieeruvad aastati vastavalt ilmastikutingimustele. Spetsiaalselt ESA satelliidi Envisat spektromeetri MERIS jaoks loodud klorofülli maksimumi indeksit (MCI) kasutasime sinivetikate sesoonse dünaamika, ruumilise jaotuse ja katvuse uurimiseks Peipsis ja Võrtsjärves. Selgus, et MCI abil saadud hinnangud on heas vastavuses eelnevate teadmistega fütoplanktoni jaotusest neis järvedes, mille optilised omadused on võrreldavad Läänemere rannikuvetega.

Taimkatte kaugseirajad tegid A. Kuuse juhtimisel ulatuslikke välitöid Järvselja katsealal. Rahvusvahelise kiirguslevi mudelite võrdluse (RAMI) neljandas faasis kasutati simuleeritud taimekoosluse asemel esmakordselt reaalseid looduslikke taimekooslusi. Metsa kiirguslevi mudelite puhul olid kuuest testkooslusest tervelt kolm valitud meie Järvselja katsealalt.

Maapealseid spektri- ja struktuurimõõtmisi toetasid kosmosevaatlused ESA eksperimentaalsatelliidilt PROBA ning lennukimõõtmised meie enda konstrueeritud spektromeetritega UAVSpec2 ja UAVSpec4 ning Maa-ameti laserskanneriga. Esmakordselt laienesid spektraalmõõtmised ka keskmisse infrapunapiirkonda (0.9–1.7 μm).

Taimkatte peegeldusomadusi kujundab fütoelementide (lehed, okkad, oksad) hulk ja paiknemise muster ning sellest tingitud tühikute suurus ja hulk. Just seda kiirgusleviks olulist metsade struktuuri omadust uuris T. Nilson koos teadlastega Kanadast ja USA-st. Meie välja töötatud Kuuse-Nilsoni metsa peegeldusmudel FRT ja Nilsoni metsa puuderinde läbipaistvuse valemid leidsid kasutamist ka Eestist looduslikult väga kaugetes piirkondades, näiteks Hiinas ja Kalifornias.

Taimkatte struktuuri mitmekesisuse universaalsemaks kirjeldamiseks taimkatte kiirguslevis on J. Knyazikhini (Bostoni Ülikool) algatusel ning koostöös P. Stenbergi (Helsingi Ülikool) ja M. Mõttusega kasutusele võetud spektraalsete invariantide meetod. Meetod baseerub kiirguslevi operaatori omaväärtusülesande lahendamisel. Spektraalsete invariantide abil saab taimkatte poolt neelatud, peegeldunud ja taimkattest läbi tulnud kiirgust kirjeldada vähese hulga lainepikkusest sõltumatute parameetritega. M. Mõttuse teoreetilised uuringud näitasid veel ühe spektraalse invariandi kasulikkust kiirguse hajumise suundolenevuse kirjeldamisel taimkattes. T. Nilson ja M. Mõttus leidsid analüütilised lahendid kiirguslevi operaatori omavektoritele kahe voo lähendis.

5.1 Solar UV radiation and atmospheric ozone

For the group of solar UV radiation and atmopheric ozone research one of the major tasks was putting into practice the double monochromator DMc150F-U based system for recording of the solar UV spectra in the spectral range 280–400 nm. The instrumentation obtained in the framework of the EstSpacE project was installed in the pavilion of the Tartu-Tõravere Meteorological Station by U. Veismann and other members of the group. The location is close to other solar radiation recording instruments as well as to the AERONET sunphotometer. The radiation collecting diffuser is placed on the roof of the pavilion and connected with a quartz fibre to the double monochromator spectrometer placed in a special weather box in the building. The control of operation and data recording are made by a computer placed close to the spectrometer. The automatic recording of spectra during a daytime is performed in each 15 minutes simultaneously with the recording of spectra by the CCD array spectrometer placed in the main building of the Tartu Observatory. The distance between the locations of two instruments is about 250 m.

I. Ansko together with J. Envall has made additional measurements of characteristics of the array spectrometer AvaSpec-256 at the Metrology Research Institute, University of Helsinki (Finland) and improved the reliability of subtraction of the stray light at the shortest wavelengths. Also the comparisons of spectra recorded simultaneously by both spectrometers at Tõravere were performed.

The results of preliminary comparison of spectra recorded by the AvaSpec-256 in cloudless and overcast conditions were presented in MSc thesis of M. Prüssel. The comparison of UV-A and UV-B noon irradiances and daily doses showed that on cloudy days the values were only 35% of the cloudless day ones on average. The attenuation by clouds depends on wavelength of radiation. In the $UV - A$ region, where there is no influence of ozone, clouds attenuate more radiation at longer wavelengths than at shorter. In the UV-B region the clouds as optically thick medium increase the probability of absorption by tropospheric ozone. The values of the ratio UV-B/UV-A decreased by 7% in overcast conditions on average.

The recorded data sets of UV radiation are still relatively short in time and there is an urgent need for their reconstruction for past years. In 2004–2009 K. Eerme and the other members of the group have participated in the COST 726 action for the reconstruction and climatology of erythemally weighted UV radiation over Europe. Now the reconstruction of UV-B irradiance levels is getting actual. It needs special study of the potential proxy quantities for such reconstruction and also understanding and estimating the environmental effects of UV-B radiation. Environmental effects of the UV-B irradiance at any site depend strongly on the presence of direct sunshine and

on solar elevation. Daily sum of direct irradiance is more appropriate measure of sunshine than is the daily sunshine duration. However, the latter is recorded more widely and often a necessity arises to estimate the effects of solar radiation from it. The daily data of direct irradiance and sunshine duration recorded simultaneously at the Tartu-Tõravere Meteorological station in 1967–2008 were studied by K. Eerme, U. Veismann and I. Ansko from the point of view how to transform the relative sunshine duration into the relative direct irradiance. The ranges of variation for direct irradiance have been larger than these for sunshine duration. The average monthly values of the ratio of relative direct irradiance to the relative sunshine duration reached its smallest value, around 0.8, in July and August, and then increased to the level close to 1 from December to February, when the sunshine is not regularly obscured around noon. The monthly average daily direct irradiances could be estimated statistically from the daily relative sunshine duration.

Figure 5.1: Bentham DMc150F-U spectrometer. Bentham DMc150F-U spektromeeter.

The measurement data of solar irradiance as well as other climate characterizing data are often analysed for detecting their trends and variations in time. In the cases of wide and asymmetric distributions, the conventional mean may turn out to be not robust enough as a summary measure, therefore the derived trends would also be nonadequate. The daily relative sums of ground-level pyranometer-measured global irradiance, the daily values of aerosol optical depth and total ozone on site of Tartu Observatory and Tartu-Tõravere Meteorological station have been studied from this point of view by K. Eerme, U. Veismann and I. Ansko. The agreement between the mean, median and trimmed median (trimean) as well as that between different spread characteristics has been studied. The use of the conventional mean instead of the trimean leads to overestimation of the central tendency in the daily relative global irradiance from October to February by 4.5% to 14% on average, depending on the month. In separate years the overestimation reaches 30–40%. From April to August the conventional mean leads to underestimation of the central tendency in relative global irradiance by about 2.5% as compared to that of the

trimean. The slopes of all the calculated linear trends were found to be the smallest in the case of using the conventional mean as a central tendency measure. It leads to the underestimation of the dimming and brightening trends. In winter months there has appeared an overall decreasing tendency of relative global irradiance in recent two decades; using the conventional mean this dimming trend is underestimated in some cases by up to 20–30% as compared to the trend calculated from the trimean.

The distribution of aerosol optical depth on the study site has also been highly asymmetric. In 2002–2008 the conventional mean of the aerosol spectral optical depth at AERONET wavelengths was about 25% to 30% larger than the trimean. Significant biases were also found in the monthly values.

5.2 Earth atmosphere and climate

Analysis of the measurement data of a CIMEL sunphotometer at Tõravere (V. Russak) has shown peculiarities in the annual mean course of some aerosol characteristics. Since the late summer the Ångström exponent as well as the role of scattering in solar radiation extinction had a tendency to decrease. This is, likely, the result of the interaction of aerosol particles with water vapour in high relative humidity conditions leading to increase the size of aerosol and change in its optical properties.

5.3 Remote sensing of water bodies

Detection of heavy phytoplankton blooms over the Baltic Sea and large lakes became a new aspect of our research. Cyanobacterial blooms occur every year in the Baltic Sea and they cover thousands of square kilometers. Similar phenomena, however with different species compositions, happens also in lakes Peipsi, Pihkva and Võrtsjärv. Together with Swedish Meteorological and Hydrological Institute (SMHI) we developed method for operational monitoring of surface scum of cyanobacterial blooms, as this is one of the parameters requested also by European Water Framework Directive. SMHI has been operating a daily monitoring service of the cyanobacterial blooms since 2002 on the basis of NOAA-AVHRR satellite data. To improve the service the new procedures will be using water quality sensors like MERIS/Envisat and MODIS/Aqua & Terra, which provide higher spatial resolution (around 300 m).

Maximum Chlorophyll Index (MCI) developed for MERIS processing scheme is used to investigate seasonal dynamics, spatial distribution, and coverage of cyanobacterial blooms over Lake Peipsi and Võrtsjärv. The MCI-derived results are consistent with known patterns of phytoplankton dynam-

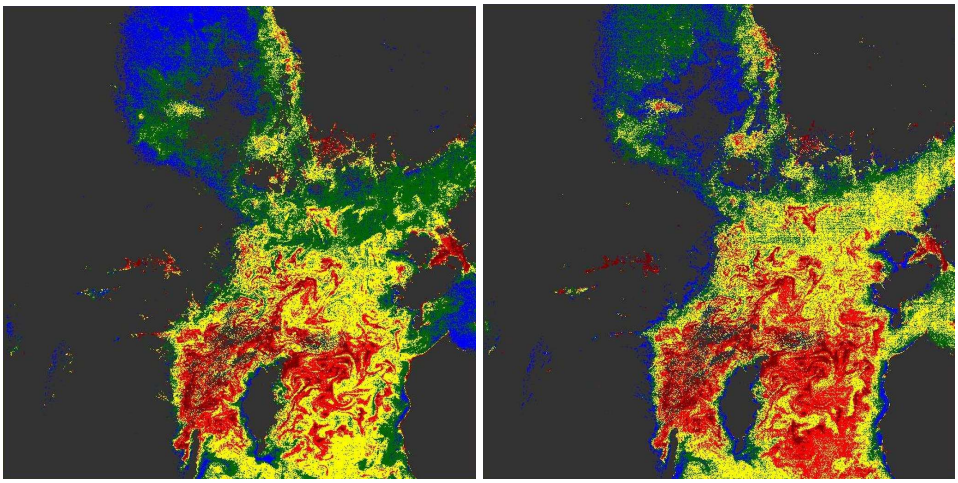


Figure 5.2: MERIS/Envisat normalized water leaving radiance at 560 nm (left) and 665 nm (right) from 25 July 2008. Last colour in the scale indicates surface scum. MERIS/Envisat normeeritud veest tagasihajunud kiirgus kanalites 560 nm (vasak) ja 665 nm (parem) 25. juulil 2008. Viimane värv värvusskaalal viitab pinnakogumite võimalusele.

ics in these lakes, which optical properties are in the same range as in many coastal regions of the Baltic Sea.

For the MERIS images over Baltic Sea regions the method developed for MODIS using normalized water leaving radiances at 555 nm or at 670 nm and Level 2 flags proposed by Kahru et al. 2007 was applied for the first time and preliminary results coincide with each other well as shown in Figure 5.2.

5.4 Remote sensing of vegetation

In July 2009, TRAC measurements of gap size distribution with Tracing Radiation and Architecture of Canopies (TRAC) instrument were acquired for 175 transects under various angular configurations at the three Järvselja RAMI stands (J. Pisek).

The six different methods for analysing foliage nonrandomness by means of the TRAC instrument, digital hemispheric photography, and gap fraction models were assessed at birch and pine RAMI stands in Järvselja. It was concluded that the gap size distribution and beyond-shoot clumping is very stable across the stands for the solar zenith angle range from 30 to 60 degrees. Estimates based on the combination of gap size and logarithm methods performed the best while compared with an independent gap fraction model of Nilson (1999). The sensitivity of the methods to the segment length was highlighted, and an approach was proposed how to select the appropriate length

for TRAC measurements. Also the effect of the assumed leaf inclination angle distribution on gap size distribution and differences between clumping factor estimates was clarified (J. Pisek, M. Lang, L. Korhonen (Joensuu University), T. Nilson)).

Extensive field studies at the satellite test site at Järvselja were carried out. The database describing three mature forest stands of 100x100 m is the test data in the fourth phase of the RAdiation transfer Model Intercomparison (RAMI). Ground-based spectral and structure measurements are supported by atmospherically and radiometrically corrected hyperspectral CHRIS data of ESA experimental satellite PROBA, top-of-canopy reflectance measurements with the airborne spectrometer UAVSpec developed in our research group, and airborne laser scanner measurements (A. Kuusk, J. Kuusk, M. Lang). Lidar data revealed differences in vertical profiles of foliage in studied stands. Canopy cover estimates from lidar data confirm the reliability of allometric estimates of canopy cover by M. Lang.

A. Kuusk took part in the RAdiation transfer Model Intercomparison (RAMI) with forest radiative transfer model FRT developed at Tartu Observatory. In the fourth phase of RAMI actual canopies and field data are used as simulation targets first time during about ten years of radiative transfer model intercomparisons at RAMI. Together with the team of University of California, Berkeley the performance of Nilson (1999) gap fraction formula for forest canopies was tested in an open savanna ecosystem of California oak (Ryu et al. 2010). The angular course of gap fraction as predicted by the formula showed good agreement with that of measured by LAI-2000 instrument. A new analytical formula was proposed to quantify the beyond-shoot level clumping index in forest stands.

Together with a Chinese team of some Beijing institutions the forest reflectance model FRT was used for the estimation of overstory and understory leaf area index (A. Kuusk). Using the inversion of physical reflectance models instead of vegetation indices for the interpretation of remote sensed data offers the advantage that we can use numerous spectral bands simultaneously instead of only the two to four bands used in vegetation indices. The method is ready for using multiple remote-sensing information, e.g. multi-angle hyperspectral images provided by instruments such as CHRIS/Proba. The use of multi-angle data can throw light on the internal structure of vegetation canopies (partitioning into overstory and understory, e.g.) which is hard to distinguish when using spectral data in a single view direction.

For the first time, UAVSpec4 with spectral range of 900–1700 nm was used alongside UAVSpec2 for top-of-canopy reflectance measurements. This expanded the spectral region to previously unattainable short wave infrared (SWIR) domain (J. Kuusk, A. Kuusk, M. Lang). Angular distribution of reflectance of several forest stands was measured at near infrared (NIR) spec-

tral region (800 nm) (J. Kuusk, A. Kuusk, M. Lang).

Dark current temperature dependence of several miniature spectrometer modules was extensively studied and a correction algorithm was developed. This is necessary for autonomous airborne spectrometer systems which work in variable environmental conditions and where frequent measurements of dark current are not feasible (J. Kuusk). Several flight tests of the autonomous helicopter JR Voyager GSR260 for the spectroscopic measurements of forests were carried out.

J. Kuusk together with I. Ansko and J. Envall made additional measurements of the instrument function of several spectrometers at the Metrology Research Institute, University of Helsinki (Finland) and verified the quality of previous measurements carried out with the equipment available at Tartu Observatory.

J. Kuusk measured the reflectance of wheat and barley fields of international organic nitrogen long-term fertilization experiment (IOSDV - Internationale Organische Stickstoffdauerdüngungversuch) at Eerika with FieldSpec Pro VNIR spectrometer. The results are used for studies of photochemical reflectance index (PRI).

U. Peterson together with A. Kiviste and A. Kardakov from Estonian University of Life Sciences estimated the effect of stand variables on radiance of forest patches that were regenerating after the disturbance of clearcut felling. Analysis was performed on a difference image of a two-date Landsat Thematic Mapper (TM) image pair made in plain snow cover conditions – a non-traditional season for forest mapping.

The results of the study show that in all spectral bands studied (TM1–TM4), there is a significant effect of patch age, i.e. time passed since disturbance of clearcut logging, on the radiance difference of regenerating patches on a difference image. Radiance change in none of the Landsat TM bands 1–4 was found more sensitive than others to patch variables. The marginal effect of Spruce index, a binary variable denoting whether the patch was managed as a young spruce stand or a deciduous stand, means that the chance for discrimination of young spruce-dominated stands from deciduous-dominated stands in winter images is low in most cases. No significant effect of stand variables on patch-wise differences was found between the patch areas classified from difference image to that represented in the forestry database. There was a significant effect of the type of neighbours – either bright or dark – on the estimation of the patch area on a difference image.

In most remote sensing applications the amount of vegetation is commonly quantified using leaf area index (LAI), or the total one sided leaf area of the vegetation canopy per unit ground area. However, to describe both the radiation regime inside the canopy (including levels of photosynthetically active radiation available to the plant or cooling rates), LAI alone does

not suffice. Different canopy geometries can display very different radiative properties and additional canopy variables are required to account for these structural effects. The spectral invariants theory aims to parametrize canopy absorption, reflectance and transmittance using a few spectrally constant parameters. The theory is based on the eigenvalue problem for the radiative transfer operator. Thus, spectral invariants should provide information complimentary to the amount of canopy, or LAI, in a mathematically elegant and computationally efficient way. To investigate the limits of the applicability of the theory of spectral invariants, T. Nilson and M. Mõttus derived the analytical expression for the eigenvectors of radiative transfer operator for the two-stream equation. Additionaly, theoretical studies by M. Mõttus indicated the usability of the second spectral invariant to describe the directionality of canopy scattering.

6 Publications Publikatsioonid

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Gutierrez L., *Tamm A.*, Beckman J. E., Abramson L., Erwin P., Guittet M.: Where have all the Bulges gone? In: *The Galaxy Disk in Cosmological Context: Proceedings of the IAU Symposium 254. Copenhagen, Denmark, June 9–13, 2008*, eds. J. Andersen, J. Bland-Hawthorn and B. Nordström, Cambridge University Press, 506, 2009.

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Metsamaa L., *Reinart A., Alikas K.,* Kutser T., Jaanus A.: Accordance of MERIS Standard Products over the Gulf of Finland to the Parameters Measured Under Regular Monitoring Program. In: *Innovations in Remote Sensing and Photogrammetry*, eds. S. Jones and K. Reinke, Springer Verlag, 443–454, 2009.

Rautiainen M., Nilson T., Lükk T.: Empirical and Simulated Seasonal Reflectance Courses of Hemiboreal Forests. In: *Proceedings of the Fifth International Workshop on the Analysis of Multi-temporal Remote Sensing Images. Groton, Connecticut, Multi-Temp, July 28–30, 2009, USA*, 396–400, 2009.

6.3 Popular Articles Aimeartiklid

6.3.1 Astronomy Astronoomia

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Tamm A.: Kvasarite tabamata ime. *Horisont 4*, 24–31, 2009.

Tago E.: Eesti astronoomia kõrghetked. *E-raamat "Tartu Tähetorn 200".*

Tempel E.: Uued tõendid tumeaine kohta kääbusgalaktikates. *Vaatleja 2*, 2009.

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Kallis A.: Esimene ilmajaam oli tuletornis. *Maaleht*, 21.05.2009.
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6.4 Preprints Preprindid

Coziol R., Andernach H., Caretta C.A., Alamo-Martinez K.A., *Tago E.*: The Dynamical State of Brightest Cluster Galaxies and the Formation of Clusters [astro-ph/0903.2360].
Hütsi G.: Power Spectrum of the maxBCG Sample: Detection of Acoustic Oscillations Using Galaxy Clusters [astro-ph/0910.0492].
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Lietzen H., Heinämäki P., Nurmi P., *Tago E., Saar E., Liivamägi J., Tempel E., Einasto M., Einasto J., Gramann M.*, Takalo L.O.: Environments of Nearby Quasars in Sloan Digital Sky Survey. (ftp://ftp.aai.ee/pub/users/erik/sdssQSO/sdss13.pdf) [astro-ph/0904.0558].
Nakamura G., *Hütsi G.*, Sato T., Yamamoto K.: Constraint on the Growth Factor of the Cosmic Structure from the Damping of the Baryon Acoustic Oscillation Signature [astro-ph/0910.2513].

Pelt J., Korpi M.J., Tuominen I.: Solar Active Regions: a Nonparametric Statistical Analysis [astro-ph/0908.4155].

Tempel E., Einasto J., Einasto M., Saar E., Tago E.: Anatomy of Luminosity Functions: the 2dFGRS Example [astro-ph/0805.4264].

7 Meetings Konverentsid ja seminarid

7.1 Astronomy Astronoomia

Opening Ceremony of the International Year of Astronomy (UNESCO, Paris, France, 13.01.–18.01.2009) – K. Annuk, M. Ruusalepp.

IAU Symposium 260 "The Role of Astronomy in Society and Culture" (UNESCO, Paris, France, 19.01.–23.01.2009) – L. Leedjärv.
Leedjärv L.: Astronomy in the Society and Culture of Estonia (oral presentation).

Astronomical Seminar (International Center for Relativistic Astrophysics (ICRA), Rome, Italy, 20.03.2009) – J. Einasto.
Einasto J.: Evidence for the Primordial Formation of Supercluster-Void Network (oral presentation).

GREAT (Gaia Research for European Astronomy Training) Kickoff Meeting (Institute of Astronomy, University of Cambridge, Cambridge, United Kingdom, 26.03.–27.03.2009) – I. Kolka, A. Tamm.

EuroVO-AIDA School 2009 (Garching, Germany, 28.03.–02.04.2009) – E. Tempel, T. Tuvikene.

Astronomical Seminar (International Center for Relativistic Astrophysics (ICRA), Rome, Italy, 28.03.2009) – J. Einasto.
Einasto J.: The Evolution of Voids (oral presentation).

Astronomical Seminar (University of Rome, Rome, Italy, 30.03.2009) – J. Einasto.
Einasto J.: The Role of Phases in Cosmic Web (oral presentation).

Astronomical Seminar (University of Rome, Rome, Italy, 31.03.2009) – J. Einasto.
Einasto J.: The Formation of Voids and Filaments (oral presentation).

JENAM 2009. European Week of Astronomy and Space Science (University of Hertfordshire, Hatfield, United Kingdom, 20.04.–23.04.2009) – L. Leedjärv.

"The Sun, the Stars, the Universe and General Relativity", International Conference in Honour of Ya.B. Zeldovich 95th Anniversary (Minsk, Belarus, 20.04.–23.04.2009) – J. Einasto.
Einasto J.: Large Scale Structure of the Universe (oral presentation).

Nordic Optical Telescope Scientific-Technical Committee Meeting (Nordic Optical Telescope, La Palma, Spain, 11.05.2009) – T. Liimets.
Liimets T.: Astronomy in Real Time (oral presentation).

Galaxies in Isolation: Exploring Nature vs. Nurture (Granada, Spain, 12.05.–15.05.2009) – J. Vennik.
Vennik J., Hopp U.: Properties of Galaxies in and Around the Groups of Galaxies (poster).

Scientific Writing for Young Astronomers (Blankenberge, Belgium, 18.05.–20.05.2009) – M. Burmeister, L. J. Liivamägi, E. Tempel.

Workshop "Physics of Relativistic Flows" (Stockholm, Sweden, 01.06.–03.06.2009) – I. Vurm.

Nordic-Baltic Optical/NIR and Radio Astronomy Summer School "Star Formation in the Milky Way and Nearby Galaxies" (Tuorla Observatory, Finland, 08.06.–18.06.2009) – T. Liimets.

VII Serbian Conference on "Spectral Line Shapes in Astrophysics" (Zrenjanin, Serbia, 15.06.–19.06.2009) – A. Sapar, L. Sapar.

Sapar A.: Modelling of Mercury Isotope Separation in CP Stellar Atmospheres: Results and Problems (oral presentation).

Harvesting the Desert: the Universe Between Redshifts 1 and 3 (Marseille, France, 29.06.–03.07.2009) – A. Tamm.

12th Marcel Grossmann Meeting (Paris, France, 12.07.–19.07.2009) – J. Einasto, P. Einasto, E. Saar.

Einasto J.: Two Hundred Years of Galactic Studies in Tartu Observatory (oral presentation).

Summer School "Computational Astrophysics" (Princeton, USA, 13.07.–24.07.2009) – I. Vurm.

XXVII General Assembly of the International Astronomical Union (Rio de Janeiro, Brazil, 03.08.–14.08.2009) – L. Leedjärv, J. Pelt.

FinCOSPAR Meeting (Rokua, Finland, 03.09.–05.09.2009) – I. Vurm.

Vurm I.: Spectral States of Black Holes (oral presentation).

ASTRONET Board Meeting (Paris, France, 09.09.–10.09.2009) – L. Leedjärv.

Program "Solar and Stellar Dynamos and Cycles" (NORDITA, Stockholm, Sweden, 04.10.–11.10.2009) – J. Pelt.

Pelt J.: Kinematics and Statistics on the Sphere – About Spots and "Flip-flop" (oral presentation).

Pelt J.: Kinematics and Statistics on the Sphere – Supplement (oral presentation).

TTÜ matemaatika-loodusteaduskonna teaduskonverents (Tallinn, Estonia, 09.10.2009) – V.-V. Pustynski.

Pustynski V.-V.: EHB tähtede tekkimisest ja saladustest (oral presentation).

Hunting for the Dark: The Hidden Side of Galaxy Formation (Malta, 19.10.–23.10.2009) – J. Vennik.

Vennik J.: Testing Galaxy Evolution in Group Environment. The NGC 6962 Group (poster).

FERMI Symposium (Washington DC, USA, 02.11.–05.11.2009) – I. Vurm.

XXI Canary Islands Winter School of Astrophysics "Accretion Processes in Astrophysics" (Puerto de la Cruz, Tenerife, Spain, 02.11.–13.11.2009) – M. Burmeister.

Mathematics and Astronomy: A Joint Long Journey (Madrid, Spain, 23.11.–27.11.2009) – V.-V. Pustynski.

Pustynski V.-V., Pustylnik I.: Modelling Formation Range of Close Binary EHB Systems (poster).

7.2 Atmospheric physics Atmosfäärifüüsika

NordAquaRemS, Kick-off Meeting (Lammi Biological Station, Finland, 14.01.–16.01. 2009) – A. Reinart, K. Alikas, K. Uudeberg.

Alikas K.: Application of MERIS Water Quality Products for Monitoring Inland Waters (oral presentation).

Uudeberg K.: *In situ* Radiometric Measurements with TriOSRAMSES System (oral presentation).

MERIS Validation Meeting (Faros, Portugal, 01.03.–05.03.2009) – A. Reinart.

6th EARSeL SIG IS Workshop "Imaging Spectroscopy: Innovative Tool for Scientific and Commercial Environmental Applications" (Tel-Aviv, Israel, 16.03.–19.03.2009) – A. Kuusk, J. Kuusk, M. Mõttus, M. Rautiainen.

Kuusk A., Kuusk J., Lang M.: A Database for the Validation of Forest Reflectance Models (poster).

Mõttus M., Rautiainen M.: Direct Retrieval of the Shape of Leaf Spectral Albedo from Multiangular Hyperspectral Earth Observation Data (oral presentation).

Mõttus M., Lewis M., *Rautiainen M.*, Fuentes S.: A Physically-based Approach for Interpreting Hyperspectral Imagery of Eucalyptus Woodlands in South Australia (poster).

Rautiainen M., Nilson T., Lükk T.: Seasonal Reflectance Dynamics of Hemiboreal Birch Stands (poster).

Seminar at Estonian University of Life Sciences, Institute of Forestry and Rural Engineering (Tartu, 03.04.2009) – M. Lang.

Lang M.: Läbipaistvuse mõõtmine metsas (oral presentation).

COST 726 Final Seminar (Warsaw, Poland, 13.05.–14.05.2009) – K. Eerme.

Developments in Water Quality Monitoring in Estonian Waters Using Close-Range and Satellite Remote Sensing Technologies (Tartu, Estonia, 13.05.2009) – A. Reinart, U. Peterson, S. Lätt, I. Ansko.

Eerme K.: Comparison of the Daily Direct Irradiance and Sunshine Duration (oral presentation).

IAGLR (International Association for Great Lakes Research) 52nd Annual Conference on Great Lakes Research (Toledo, Ohio, USA, 18.05.–22.05.2009) – K. Alikas.

Summer School "Physical Oceanography of the Baltic Sea" (Tvärminne, Finland, 11.06.–16.06.2009) – K. Uudeberg.

Fifth International Workshop on the Analysis of Multi-temporal Remote Sensing Images (Groton, Connecticut, USA, 28.07.–30.07.2009) – M. Rautiainen.
Rautiainen M., Nilson T., Lükk T.: Empirical and Simulated Seasonal Reflectance Courses of Hemiboreal Forests (poster).

Second European Large Lakes Symposium 2009 (Norrtälje, Sweden, 10.08.–14.08.2009) – U. Peterson.
Peterson U., Liira J., Feldmann T., Mäemets H.: Patterns and Dynamics of Coastal Vegetation in Two Great Shallow Baltic Lakes in Multi-Temporal Satellite Images (oral presentation).

Workshop "Remote Sensing and Water Optics Specifically for Baltic Sea Conditions" (Tallinn, 20.08.–21.08.2009) – A. Reinart, K. Alikas, I. Ansko.
Alikas K.: Detecting Cyanobacterial Blooms in Large North European Lakes and Baltic Sea using MERIS Images (oral presentation).
Reinart A.: Investigations of the CDOM Rich Pärnu Bay by *in situ* and Remote Sensing Measurements (oral presentation).

AGA 11th Scientific Assembly (Sopron, Hungary, 23.08.–30.08.2009) – K. Eerme.

Hyperspectral Data For Ecological Applications (Castellon, Spain, 24.09.–25.09.2009) – M. Mõttus.
Mõttus M.: Physical Interpretation of p and Spectral Invariants (oral presentation).

Metsanduse arengukava töörühma koosolek (Tallinn, 13.10.2009) – M. Lang.
Lang M.: Kõrvalseisja ja kasutaja pilguga statistilisest metsainventuurist Eestis (oral presentation).

MVT (MERIS Validation Team) Meeting (Oslo, Norway, 19.10.–21.10.2009) – A. Reinart, J. Envall, I. Ansko.
Ansko I., Envall J., Kuusk J., Reinart A.: Characterisation of Remote Sensing Spectrometers (oral presentation).

Nordic Remote Sensing Days (Helsinki, Finland, 22.10.–23.10.2009) – A. Reinart, A. Kuusk, T. Nilson, U. Peterson, M. Mõttus, J. Kuusk, J. Envall, K. Alikas, J. Pisek, I. Ansko.
Envall J.: ESTCube Mission – Testing the Electric Sail with the First Estonian Satellite (oral presentation).
Mõttus M.: Reflectance of Forests: from Shoots to Global Models (oral presentation).
Peterson U.: Edge Proximity Influence on Radiance at Forest Edges on a Very High Resolution IKONOS Winter Satellite Image (oral presentation).
Pisek J.: Measuring Gap Size Distribution and Beyond-Shoot Clumping at Järvselja RAMI (RAdiation transfer Model Intercomparison) Test Sites (oral presentation).
Rautiainen M., Nilson T., Lükk T.: Seasonal Reflectance Courses of Hemiboreal Birch Forests (poster presentation).

Seirefoorum 2009. Atmosfääri seire. (Tallinn, Estonia, 05.11.2009) – K. Eerme, A. Kallis, Anu Reinart, Aivo Reinart, M. Prüssel.
Eerme K., Veismann U., Ansko I.: Ultraviolettkiirgus ja atmosfääri seisund (oral presentation).

GMES AC Meeting (Brussels, Belgium, 10.11.–12.11.2009) – A. Reinart.

COST Action ES0903 Seminar (Brussels, Belgium, 22.11.–24.11.2009) – M. Lang.

Metsakorraldus 90 (Tallinn, 09.12.2009) – M. Lang.
Lang M.: Järvselja metskond läbi aegade – paberilt geoinfosüsteemini (oral presentation).

MISR Data Users Science Symposium (Pasadena, USA, 10.12.–11.12.2009) – J. Pisek.
Pisek J., Chen J.M.: Impacts of Including Forest Understory Information from Multi-Angular Measurements in Leaf Area Index Mapping over North America (oral presentation).

7.3 Miscellaneous Muud koosolekud ja ettevõtmised

EURISY Workshop "Securing Human Resources for the Future Space Sector" (Prague, Czech Republic, 12.03.–13.03.2009) – L. Leedjärv.

Teaduse populariseerimise alane nõupidamine (Tallinn, Estonia, 28.04.2009) – K. Annuk, A. Puss, M. Ruusalepp, U. Veismann.

European High-Level Space Policy Group Meeting (Brussels, Belgium, 06.05.2009) – L. Leedjärv.

GMES Global Land Workshop (Stresa, Italy, 06.05.–07.05.2009) – M. Lang.

6th Space Council – Meeting of the European Space Ministers (Brussels, Belgium, 29.05.2009) – L. Leedjärv.

Complementary advanced training course for PhD students to use software package BEAM (Brockmann Consult) (Tallinn, Estonia, 22.08.–23.08.2009) – K. Alikas, I. Ansko.

Üleriigiline terminoloogianõupidamine (Tallinn, Estonia, 28.08.2009) – U. Veismann.

European High-Level Space Policy Group Meeting (Paris, France, 02.09.2009) – L. Leedjärv.

Teadus ja innovatsioonimeedia konverents "Bermuuda kolmnurk" (Tallinn, Estonia, 09.09.2009) – K. Annuk, L. Leedjärv, M. Ruusalepp, U. Veismann.

European High-Level Space Policy Group Meeting (Paris, France, 02.10.2009) – L. Leedjärv.

High-Level Conference "The Ambitions of Europe in Space" (Brussels, Belgium, 15.10.–16.10.2009) – L. Leedjärv.

Study trip of Estonian entrepreneurs and public sector to ESA/ESRIN and to the Italian Space Agency (Frascati and Rome, Italy, 27.10.–30.10.2009) – L. Leedjärv.

Eesti Füüsika Seltsi täppisteaduste sügiskool (Voore, Estonia, 30.10.–01.11.2009) – I. Ansko, T. Eenmäe, J. Envall, M. Noorma, A. Reinart.

XIV International Astronomy Olympiad (Hangzhou, China, 07.11.–16.11.2009) – T. Eenmäe.

European High-Level Space Policy Group Meeting (Paris, France, 02.12.2009) – L. Leedjärv.

7.4 Meetings at Tartu Observatory Tartu Observatooriumis korraldatud konverentsid

Kaugseire doktorantide seminar Tõraveres, 27.03.2009.

Alikas K.: MERIS tulemid järvede jaoks (oral presentation).

Kuusk J., Kuusk A., Lang M., Kallis A.: Hemi-boreaalsete metsade peegeldumisspekter kuival ja tavalisel suvel (oral presentation).

7.5 Meetings organized by EstSpacE team at Tartu Observatory. EstSpacE grupi poolt korraldatud üritused Tartu Observatooriumis

7.5.1 Nordic Ozone and UV Group Meeting

On April 2nd and 3rd the group of atmospheric sensing organized a regular annual Nordic Ozone Group (NOG) meeting 2009 in Pärnu, Estonia. Such meetings have been held regularly in different countries. 25 participants from 12 scientific institutions and organizations of Estonia, Finland, Norway, Sweden, Denmark, Poland and Greece listened 21 presentations on atmospheric ozone, solar and artificial (solarium) UV radiation. The meeting was supported by EstSpacE. Following presentations were made by the Estonian participants:

Biduljak I., Eerme K.: The influence on the atmosphere by civil aircrafts flying through Estonia (oral presentation).

Prüssel M., Eerme K., Veismann U., Ansko I.: On the cloudiness induced variations in the spectral distribution of ground-level UV irradiance (oral presentation).

Eerme K.: On the mutual agreement of the daily direct irradiance and sunshine duration (oral presentation).

Atmosfääri seire töörühm korraldas EstSpacE'i toetusel 2.–3. aprillini 2009 Pärnus Põhjamaade Osoonigrupi (NOG) aastakoosoleku.

7.5.2 ESTCube III Workshop and visit of the Advisory Council member Pekka Janhunen

EstSpacE team member M. Noorma organized ESTCube III Workshop from April 16th to 18th, 2009 in Tallinn, Estonia. There were 19 scientists from Estonia, Finnish Meteorological Institute and Helsinki University participating in the event. The objectives of the event were to promote space science and technology in Estonia and Finland through highly visible joint Estonian-Finnish satellite mission ESTCube-1, review the results of the satellite development in Phase 0 and advise the roadmap for the research and development activities for year 2009, summer and autumn periods. All participants shared their experiences from the ESTCube Phase 0 development. The Mission Definition Review was considered extremely useful to boost developments in Phase A. The ideas were generated and plans discussed to propose a new FP7 project on the Electric Solar Sail (ESAIL) mission development late in 2009 under the Space call. Following the discussions with the researchers from Finland, the roadmap for joint research activities in the period of 2009–2012 was developed. Partners from the German Space Agency and Angström Lab of Sweden will be incorporated into the development of the ESAIL mission to increase the visibility of the joint space activities. Pekka Janhunen is from Finnish Meteorological Institute, the inventor of the Electric Solar Sail.

Lätt S.: The Mission of the First Estonian Student Satellite EstCube-1 (oral presentation).

Participants of the EstSpacE ESTCube III workshop in Tallinn. ESTCube III nõupidamisest osavõtjad Tallinnas.

M. Noorma eestvõttel toimus 16.–18. aprillini 2009 Tallinnas tudengisatelliidi ESTCube kolmas töönõupidamine. Osales ja ettekannetega esines ka

EstSpacE'i nõuandva kogu liige Pekka Janhunen Soome Meteoroloogia Instituudist, kes on elektrilise päikesepurje leiutaja.

7.5.3 Estonian-Finnish Vegetation Remote Sensing Seminar

M. Mõttus organized Estonian-Finnish Vegetation Remote Sensing Seminar from May 25th to 28th, 2009 in Tartu, Estonia. There were 17 participants from Estonia and Finland. The event was successful in enabling the participants to share their ideas, new developments and opinions in an intimate atmosphere and strengthened Estonian-Finnish cooperation in that field.

Kuusk J.: Hyperspectral reflectance measurements from unmanned aerial platform (oral presentation).

Kuusk A.: The role of hot spot in the single scattering albedo of vegetation canopies (oral presentation).

Kallel A.: Vegetation radiative transfer modelling using virtual flux decomposition (oral presentation).

Nilson T.: Once more about eigenvalues of the radiative transfer problem (oral presentation).

Mõttus M.: p explained? (oral presentation).

Lang M.: Gap fraction measurements in forests using digital hemispheric cameras and LAI-2000 (oral presentation).

M. Mõttus organiseeris 25.–28. maini 2009 Tartus Eesti-Soome taimkatte kaugseire seminari.

7.5.4 International Summer School "Future Cosmic Sky Surveys and Huge Databases"

EstSpacE team members L. Leedjärv, I. Kolka, T. Tuvikene, E. Saar and T. Lillemaa organized an international summer school about future cosmic sky surveys and huge databases from July 1st to 3rd in Tartu, Estonia. There were 41 students and researchers from 7 countries taking part in the summer school. The importance of cosmic sky surveys and connected with them huge observational and model based simulated databases is continuously growing in the astronomical research. Using the example of ESA missions Planck and Gaia, and of cosmological n-body simulations database the summer school was aimed to teach participants to understand the yield of sky surveys, and to use corresponding data through Virtual Observatory. A special part of the school was devoted to the art of scientific writing. The school activities were divided between three morning sessions and two afternoon sessions consisting of 7 lessons and 3 practical tutorials. The summer school was fruitful for all participants in developing their abilities to use huge databases and Virtual Observatory in their research efforts. The rising of knowledge on crucial

points of scientific writing was highly appreciated, too. The possibility to establish new personal collaborative contacts should be stressed in the framework of the school. The young Estonian researchers should develop further their experience in the usage of databases and Virtual Observatory by attending other special schools and workshops/meetings. It is useful to propose international collaborative projects based on the so-called data mining approach.

Lecturers of the summer school were Carlo Baccigalupi from International School for Advanced studies (SISSA), Trieste, Italy; Wolfgang Hovest and Jörg Knoche from MPA Planck Group, Germany; Gerard Lemson from Max-Planck Institute for Extraterrestrial Physics, Germany; Chris Sterken from Vrije Universiteit Brussel, Belgium and Timo Prusti, Gaia Project Scientist from ESTEC, ESA, The Netherlands.

1.–3. juulini 2009 korraldasid I. Kolka, L. Leedjärv, T. Lillemaa, E. Saar ja T. Tuvikene Tartus rahvusvahelise suvekooli, kus üliõpilastele ja teadlastele tutvustati suurte kosmiliste taevaülevaadete ja andmebaaside kasutamist. Käsitleti ka teaduslike artiklite kirjutamise põhitõdesid.

Participants of the Summer School in Tartu. Suvekoolist osavõtjad Tartus.

7.5.5 Remote Sensing and Water Optics Specifically for Baltic Sea Conditions

EstSpacE project coordinator A. Reinart organized international workshop "Remote sensing and water optics specifically for Baltic Sea conditions" from August 20th to 21st, 2009 in Tallinn, Estonia. This year the Baltic Sea Science Conference was held in Estonia and it has become already tradition that re-

mote sensing and bio-optics specialists have their own dedicated workshop in conjunction with that event (www.bssc2009.org). Researchers and students presented their latest results about application of remote sensing method to improve monitoring of the optically complex waters in the region of Baltic Sea. This time special attention was paid on atmospheric correction problems which are caused by high surface scattering during cyanobacterial bloom, low signal in blue region of spectra caused by high absorption in dissolved organic matter or specific properties of aerosol over Baltic Sea. Examples about integration of *in situ* and satellite data for better development of further GMES downstream services were another priority. There were altogether 44 participants, including trainers and organisers.

Alikas K.: Detecting Cyanobacterial Blooms in the Baltic Sea and Large North European Lakes Using MERIS Images (oral presentation).

Reinart A.: Investigations of the CDOM Rich Pärnu Bay by *in situ* and Remote Sensing Measurements (oral presentation).

EstSpacE projekti koordinaator A. Reinart korraldas 20.–21. augustini 2009 Tallinnas rahvusvahelise nõupidamise vee kaugseirest ja optikast Läänemere spetsiifilistes tingimustes.

7.5.6 International Training Course "Advanced application of BEAM software"

After the remote sensing workshop an international training course "Advanced application of BEAM software" was organized by A. Reinart from August 22nd to 23rd, 2009 in Tallinn, Estonia. There were 20 participants. Following the topic of international workshop "Remote sensing and water optics specifically for Baltic Sea conditions", 20–21 August 2009 the group intended to use BEAM software to investigate atmospheric correction using the Case2R processor which provides interesting intermediate products (such as path radiance, transmission etc), and to compare the different Case2 water processors available in BEAM (Case2R, boreal lakes, FUB) in connection with adjacency effect corrections by ICOL processor.

Vahetult pärast Läänemere-nõupidamist toimus 22.–23. augustini 2009 Tallinnas A. Reinarti korraldamisel tarkvara BEAM kasutamise kursus.

7.5.7 ESTCube IV Workshop and visit of Advisory Council member Pekka Janhunen

EstSpacE team member M. Noorma organized ESTCube IV Workshop from October 29th to November 1st 2009 in Voore, Estonia to promote space science and technology in Estonia and Finland through highly visible joint Estonian-Finnish satellite mission ESTCube-1, review the results of the satellite deve-

lopment in Phase A and advise the roadmap for the research and development activities for year 2010. There were 20 participants from 3 countries. EstSpacE advisory council member Pekka Janhunen visited Tartu Observatory and a network meeting to discuss the development of EstSpacE project was held as well. He had also lecture about physics and technological solutions of ESailing (for ESTCube student team). The roadmap for joint research activities in the period of 2009–2012 was reviewed. It was advised by the international partners and EstSpacE Advisory Council member Pekka Janhunen that additional training and summer schools have to be arranged in 2010 on specific issues related to spacecraft assembly and simulations.

29. oktoobrist 1. novembrini korraldas M. Noorma Voorel (Jõgevamaa) neljanda tudengisatelliidi ESTCube töönõupidamise. Taas osales EstSpacE'i nõuandva kogu liige Pekka Janhunen, kes selle visiidi raames külastas ka Tartu Observatooriumi Tõraveres.

7.5.8 Visit of Prof. Jing M. Chen Toronto University, Canada.

J. Pisek invited his former supervisor Prof. Jing M. Chen to visit Tartu Observatory on December 20th and 21st, 2009. During his visit a short workshop was organized for disccusions about simultaneous retrievals of vegetation structural and biochemical parameters using multi-angle and hyperspectral optical data. Three presentations by Tartu Observatory were as follows:

Lang M.: Canopy Gap Fraction Estimation from Digital Hemispherical Images Using Sky Radiance Models and a Linear Conversion Method (oral presentation).

Kuusk J.: Top-of-Canopy Reflectance Measurements with the Airborne Spectrometer UAVSpec (oral presentation).

Pisek J.: Measurements of Gap Size Distribution and Canopy Nonrandomness at Järvselja RAMI (RAdiation transfer Model Intercomparison) Test Sites (oral presentation).

20.–21. detsembrini 2009 külastas Tartu Observatooriumi ja osales minikonverentsil Toronto Ülikooli professor Jing M. Chen.

8 Visits and guests Visiidid ja külalised

8.1 Astronomy Astronoomia

T. Liimets – Nordic Optical Telescope, La Palma (Spain); most of the year 2009.
J. Einasto – International Center for Relativistic Astrophysics, Rome, (Italy); 01.03.–01.04.2009.
A. Tamm – Instituto de Astrofísica de Canarias, La Laguna (Spain); 23.01.–06.02.2009.
T. Liimets – Kapteyn Astronomical Institute, Groningen (The Netherlands); 02.03.–06.03.2009.
L. J. Liivamägi – Tuorla Observatory, Turku (Finland); 07.06.–19.06.2009.
J. Pelt – University of Helsinki, Helsinki (Finland); 14.06.–19.06.2009.
M. Gramann – Tuorla Observatory, Turku (Finland); 28.07.–07.08.2009.
V. Malyuto – Rostov State University, Rostov-on-Don (Russia); 17.08.–28.08.2009.
J. Einasto, I. Suhhonenko – Astrophysical Institute Potsdam (Germany); 11.09.–12.10.2009.
T. Liimets – Kapteyn Astronomical Institute, Groningen (The Netherlands); 15.09.–25.09.2009.
E. Tempel – Astrophysical Institute Potsdam (Germany); 13.10.–26.10.2009.
E. Saar, A. Tamm – Observatori Astronómic, Universitat de València, València (Spain); 13.10.–12.12.2009.
M. Gramann – Tuorla Observatory, Turku (Finland); 24.11.–05.12.2009.
L. J. Liivamägi – Tuorla Observatory, Turku (Finland); 24.11.–27.11.2009.
J. Einasto – ICRANet, Pescara (Italy); 01.12.–17.12.2009.
T. Liimets – Kapteyn Astronomical Institute, Groningen (The Netherlands); 07.12.–10.12.2009.

8.2 Atmospheric physics Atmosfäärifüüsika

J. Kuusk, J. Envall, I. Ansko – Metrology Research Institute, University of Helsinki (Finland); 02.02.– 06.02.2009.
K. Alikas – University of Toronto (Canada); 30.03.–30.06.2009.
M. Mõttus – University of Helsinki (Finland); 17.02.–23.02.2009; 12.05.–16.05.2009.
M. Mõttus, A. Reinart – Ventspils University College and Ventspils International Radio Astronomy Center (Latvia); 10.06.–12.06.2009.
A. Reinart, I. Ansko – Field Campaign for MERIS Validation on Lake Vänern (Sweden); 25.06.–03.07.2009.
M. Mõttus – University of Boston, Climate and Vegetation Research Group, Dept. of Geography, Boston (USA); 23.07.–07.08.2009.
J. Pisek – University of California, Berkeley (USA); 04.12.–09.12.2009.

8.3 Guests of the observatory Observatooriumi külalised

Arthur Chernin – Sternberg Astronomical Institute, Moscow State University (Russia); 25.02.–27.02.2009.

Pekka Heinämäki – Tuorla Observatory, University of Turku (Finland); 14.01.–21.01; 25.02.–27.02; 25.05.–28.05; 30.06.–03.07; 21.09.–24.09.2009.

Pekka Janhunen – Finnish Meteorological Institute, Helsinki (Finland); 16.04.–18.04.2009, 29.10.–01.11.2009.

Riho Nõmmik – Skobeltsyn Institute of Nuclear Physics, Moscow State University (Russia); 04.05.2009.

Radu Stoica – Université Lille (France); 14.05.–20.05.2009.

Jiři Kubàt – Ondřejov Observatory (Czech Republic); 02.06.–06.06.2009.

Gösta Gahm – Stockholm University (Sweden); 04.06.2009.

John Davies – UK Astronomy Technology Centre, Edinburgh (United Kingdom); 10.06.–11.06.2009.

Christiaan Sterken – Vrije Universiteit Brussel (Belgium); 29.06.–03.07.2009.

Carlo Baccigalupi – International School for Advanced studies (SISSA), Trieste (Italy); 01.07.–03.07.2009.

Wolfgang Hovest – MPA Planck Group (Germany); 01.07.–03.07.2009.

Jörg Knoche – MPA Planck Group (Germany); 01.07.–03.07.2009.

Gerard Lemson – Max-Planck Institute for Extraterrestrial Physics (Germany); 01.07.–03.07.2009.

Timo Prusti – Gaia Project Scientist, ESTEC, ESA (The Netherlands; 01.07.–03.07.2009.

Jing M. Chen – Toronto University (Canada); 20.12.–21.12.2009.

9 Seminars at the Observatory Observatooriumis toimunud seminarid

9.1 Astronomy Astronoomia

07.01.2009 – Elmo Tempel: Ülevaade talvekoolist "Local Group Cosmology".
14.01.2009 – Tõnu Viik: Eesti astronoomia alguspäevadest.
21.01.2009 – Antti Tamm: Aktiivsetest galaktikatest.
30.01.2009 – Jüri Pertman, Kristiina Türk: GPS püsijaam Tõraveres.
04.02.2009 – Elmo Tempel: Kosmoloogia – astrofüüsikaline perspektiiv.
11.02.2009 – Kalju Annuk, Laurits Leedjärv, Mare Ruusalepp: Rahvusvahelise Astronoomia Aasta 2009 avamise üritustest Pariisis.
25.02.2009 – Arthur Chernin (Moscow University): Dark Matter and Dark Energy in the Local Universe.
04.03.2009 – Arutelu: Darwin ja meie – rõõmsameelne diskussioon.
11.03.2009 – Tõnu Kipper: Elu tekkest.
01.04.2009 – Olavi Kärner: Päikesest: üks lihtne mudel päikesekiirguse ja meteojaamade õhutemperatuuri pikaajalise muutlikkuse kirjeldamiseks.
08.04.2009 – Jaan Einasto: Millal tekkisid Universumi struktuuri alged?
15.04.2009 – Jaan Einasto: Tühikute arengust.
22.04.2009 – Urmas Haud: Udujuttu pilvedest.
29.04.2009 – Taavi Tuvikene, Elmo Tempel: Virtuaalobservatooriumi võimalustest.
04.05.2009 – Riho Nõmmik (Moscow University): Päikese kosmilistele kiirtele omased seaduspärasused.
06.05.2009 – Elmo Tempel, Taavi Tuvikene: Virtuaalobservatoorium praktikas.
13.05.2009 – Tõnu Tuvikene (EENet): Kosmoseriik Holland.
03.06.2009 – Jiři Kubàt (Ondřejov Observatory): Tähetuulest.
04.06.2009 – Gösta Gahm (Stockholm University): The Fate of Globulettes.
10.06.2009 – John Davies (UKATC, Edinburgh, OPTICON Project Scientist): OPTICON; the EU Network for Optical and Infrared Astronomy.
11.06.2009 – Andi Hektor (KBFI): PAMELA, Fermi ja HESS tulemused: kas esimene mittegravitatsiooniline märk tumeainest?
17.06.2009 – Jaan Vennik: Isoleeritud galaktikatest – Granada konverentsi ainetel.
02.09.2009 – Jaan Pelt: Astronoomia kui keskkonnateadus. IAU 2009.
16.09.2009 – Laurits Leedjärv: Veel veidi IAU 27. peaassambleest Rio de Janeiros.

23.09.2009 – Urmas Haud: Külm ring.
30.09.2009 – Uno Veismann, Mare Ruusalepp, Kalju Annuk: Muljeid ja mõtteid teadus- ja innovatsioonimeedia konverentsist "Bermuda kolmnurk".
14.10.2009 – Tõnu Viik: Pierre Louis Moreau de Maupertuis – korsaari pojast Pariisi ja Berliini akadeemiate presidendiks.
21.10.2009 – Peeter Tenjes: Astronoomia õpetamisest Tartu Ülikoolis.
28.10.2009 – Arved Sapar: Paisuv homogeenne isotroopne Universum.
11.11.2009 – Tõnu Viik: Maupertuis ekspeditsioon Põhjalasse.
18.11.2009 – Tiit Sepp: Noorfüüsikute sügiskool 2009.
02.12.2009 – Tõnu Kipper: Orgaaniline aine Universumis.
09.12.2009 – Mari Burmeister: Akretsioon astrofüüsikas.
16.12.2009 – Alar Puss: VV Cep ja AX Mon.

9.2 Atmospheric physics Atmosfäärifüüsika

16.01.2009 – Margit Prüssel: UV kiirgus ja selle mõju ökosüsteemidele, materjalidele ning tervisele.
30.01.2009 – Jüri Pertman, Kristiina Türk: GPS püsijaam Tõraveres.
06.02.2009 – Erko Jakobson: Atmosfääri niiskussisalduse ajalis-ruumiline muutlikkus.
18.09.2009 – Kalju Eerme: Päikesekiirgusega varustatust iseloomustavate atmosfääri karakteristikute keskväärtuse alternatiividest Tõravere andmete põhjal.
09.10.2009 – Jan Pisek: Mapping Forest Background Reflectivity with Multi-Angle Remote Sensing to Improve Leaf Area Index Retrieval.

10 Membership in scientific organizations
Teadusorganisatsioonide liikmed

Academia Europaea – J. Einasto
Akademische Gesellschaft für Deutschbaltische Kultur – T. Viik
American Astronomical Society – J. Einasto
American Geophysical Union – K. Alikas (student member), M. Mõttus, J. Pisek, M. Rautiainen, 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, V. Harvig, 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 Geograafia Selts – A. Kallis
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 Kvaliteediühing – U. Veismann
Eesti Looduseuurijate Selts – K. Eerme, A. Kallis, V. Russak, A. Sapar, M. Sulev, U. Veismann, T. Viik (president)
Eesti Teaduste Akadeemia / Estonian Academy of Sciences – J. Einasto, A. Sapar
Eesti Teadusfondi Nõukogu – T. Viik
EUFAR (EUropean Fleet for Airborne Research): Education and Training – S. Lätt
EURISY Programmatic Steering Committee – L. Leedjärv

European Association of Remote Sensing Laboratories (EARSeL) – department of atmospheric physics

European Astronomical Society – K. Annuk, J. Einasto, M. Gramann, V. Harvig, G. Hütsi, T. Kipper, I. Kolka, L. Leedjärv, 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

Finnish Society of Forest Sciences – M. Mõttus, M. Rautiainen

The GAIA Data Processing and Analysis Consortium (DPAC), Coordination Unit CU8: Astrophysical Parameters – I. Kolka, V. Malyuto

German Astronomical Society – J. Einasto

GMES (Global Monitoring for Environment and Security) Advisory Council – A. Reinart

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. Rautiainen (secretary), M. Lang (member of steering committee), M. Mõttus (member of steering committee)

Optical Society of America – T. Viik, S. Lätt (student member)

Royal Astronomical Society – J. Einasto (associated member)

Societas Biologica Fennica Vanamo – M. Rautiainen

Ultraviolettkiirguse, osooni ja aerosoolide uurimise koordineerimise Eesti Nõukogu – K. Eerme, A. Kallis, U. Veismann

Õpetatud Eesti Selts – U. Peterson, T. Viik

Working Group 4 of COST 726 Action – S. Lätt

WMO World Climate Research Programme, Baseline Surface Radiation Network (BSRN), PAR (Photosynthetically Active Radiation) Working Group – A. Kallis

11 Teaching and Popularizing Õppetöö ja populariseerimine

11.1 Lecture courses and seminars Loengukursused ja seminarid

11.1.1 Astronomy Astronoomia

Astronomy Astronoomia – P. Tenjes, University of Tartu.
Quantum Physics Kvantfüüsika – P. Tenjes, University of Tartu.
Atomic and Subatomic Physics I Mikromaailma füüsika I – P. Tenjes, University of Tartu.
Mathematical Physics I Matemaatiline füüsika I – P. Tenjes, University of Tartu.
Relativistic Physics Relativistlik füüsika – M. Saal, University of Tartu.
The Physics of Stars Tähtede füüsika – T. Viik, University of Tartu.
Course "Amateur radio" Amatöörraadioside – T. Eenmäe, University of Tartu.
Space technology Kosmosetehnoloogia alused – T. Eenmäe, University of Tartu.
Webcourse "Astronomy" in E-University Astronoomia veebikursus e-ülikoolis – T. Eenmäe, University of Tartu.
Seminar in Astrophysics Astrofüüsika seminar – E. Tempel (together with T. Tuvikene and P. Tenjes), University of Tartu.
Building Tartu University Satellite Communication Groundstation under Estcube Student Satellite Project Tartu Ülikooli satelliitside tugijaama ehitamine Estcube tudengisatelliidi projekti raames – I. Ansko, T. Eenmäe, University of Tartu.
Open Contest in Astronomy at the Gifted and Talented Development Centre Astronoomia lahtine võistlus Teaduskoolis – T. Eenmäe, University of Tartu.
General Course of Physics Füüsika üldkursus – V.-V. Pustynski, Tallinn University of Technology.
Physics I, II Füüsika I, II – V.-V. Pustynski, Tallinn University of Technology.
Introduction to Space Flight Sissejuhatus kosmonautikasse – V.-V. Pustynski, Tallinn University of Technology.
Introduction to Physics Sissejuhatus füüsikasse – V.-V. Pustynski, Tallinn University of Technology.
Introduction to Astrophysics Sissejuhatus astrofüüsikasse – V. Harvig, Tallinn University of Technology.

Gasodynamics and Interstellar Medium *Gaasidünaamika ja tähtedevaheline keskkond* – I. Vurm (teaching assistant), University of Oulu.

Astronomy Course for the Nõo High School, held at the Observatory *Astronoomia kursus Nõo Reaalgümnaasiumi 12. klassidele, läbi viidud observatooriumis* – K. Annuk, L. Leedjärv, M. Ruusalepp, E. Saar, T. Viik.

Observational guides in Estonian language for International Year of Astronomy 2009 cornerstone project "Dark Skies Awareness" subproject Globe at Night. A webpage is created on Estonian national GLOBE website. *Rahvusvahelise Astronoomia Aasta pimeda taeva teadvustamise "nurgakivi projekti" raames Globe at Night vaatlusjuhendite eesti keelde tõlkimine ning Eesti GLOBE programmi veebilehele Globe at Night alamlehe loomine (http://www.globe.ee/gan)* – T. Eenmäe, University of Tartu.

11.1.2 Atmospheric physics Atmosfäärifüüsika

Introduction to Geophysics *Sissejuhatus geofüüsikasse* – K. Eerme, University of Tartu.

Space Technology *Kosmosetehnoloogia* – U. Veismann, M. Noorma, A. Reinart, University of Tartu.

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

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

Remote Sensing I, *Kaugseire I* – U. Peterson, University of Tartu.

Remote Sensing of 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, M. Lang, Estonian University of Life Sciences.

Geographic Information Systems *Geograafilised Informatsioonisüsteemid* – U. Peterson, Estonian University of Life Sciences.

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

Forest Inventory (MARV4/1) *Metsakorraldus* – M. Mõttus, visiting lecturer, University of Helsinki.

11.2 Popular lectures Populaarteaduslikud loengud ja esinemised

43 intervjuud BNS-ile, raadiole ja televisioonile – A. Kallis.
30+ intervjuud BNS-ile, raadiole ja televisioonile – T. Viik.
14 intervjuud raadiole ja televisioonile (Vikerraadio, ETV, Raadio Kuku, Elmar jt.) – L. Leedjärv.
7 saadet "Astronoomiaminutid" (www.astronoomia.ee/minutid) – T. Tuvikene, T. Eenmäe.
Inimene Universumis (Eesti Evangeelse Alliansi palvushommikusöök, Tartu, 06.01.2009) – L. Leedjärv.
Rahvusvahelisest astronoomia aastast (Huvitaja, Vikerraadio, 08.01.2009) – K. Annuk.
Tähed, kataloogid, taevaülevaated, kaardid ... (Kesköoprogramm, Vikerraadio, 09.01.2009) – I. Kolka, L. Leedjärv.
Rahvusvahelisest astronoomia aastast (Terevisioon, ETV, 23.01.2009) – K. Annuk.
Päikesesüsteemist ja rahvusvahelisest astronoomia aastast (Saame kokku Tomi juures, ETV, 16.02.–17.02.2009) – E. Tempel.
Eesti astronoomia alguspäevadest (Akadeemilise Baltisaksa Kultuuri Seltsi ettekandekoosolek, Tartu, 17.02.2009) – T. Viik.
Kääbusgalaktikad Kohalikus Grupis: mis nad on ja kus nad on? (Tartu Tähetorni Astronoomiaring, 17.02.2009) – E. Tempel.
Astronoomia Eestis enne ja nüüd (Eesti Looduseuurijate Selts, Tartu, 26.02.2009) – J. Einasto.
Kuidas kellad käivad? (Tartu Tähetorni Astronoomiaring, 03.03.2009) – J. Pelt.
Nibirust ja maailmalõpust (Pealtnägija, ETV, 18.03.2009) – K. Annuk.
Lihtsalt teleskoobist (Tartu Tähetorni Astronoomiaring, 19.03.2009) – T. Eenmäe.
Kuidas tekivad ja arenevad galaktikad (Huvitaja, Vikerraadio, 19.03.2009) – E. Tempel.
Eksoplaneetidest (Konverents "Ööbikuoru tähed", Rõuge, 21.03.2009) – T. Viik.
Kuidas tekivad ja arenevad galaktikad (Konverents "Ööbikuoru tähed", Rõuge, 22.03.2009) – E. Tempel.
Tähed tumedas Universumis (Konverents "Ööbikuoru tähed", Rõuge, 22.03.2009) – L. Leedjärv.
Tähistaevas ja hobiastronoomia (Huvitaja, Vikerraadio, 20.03.2009 ja 27.03.2009) – T. Eenmäe.
Valgusreostus ja Globe at Night (Saade "Osoon", ETV, 23.03.2009) – T. Eenmäe.

Astronoomiast Eesti ühiskonnas (Konverents "200 aastat Universumi uudistamist Eestis", Eesti Teaduste Akadeemia, Tallinn, 25.03.2009) – L. Leedjärv.

Rahvusvahelisest astronoomia aastast (Konverents "200 aastat Universumi uudistamist Eestis", Eesti Teaduste Akadeemia, Tallinn, 25.03.2009) – K. Annuk.

Eesti astronoomia alguspäevadest (Konverents "200 aastat Universumi uudistamist Eestis", Eesti Teaduste Akadeemia, Tallinn, 25.03.2009) – T. Viik.

Kuidas tekivad ja arenevad galaktikad (Konverents "200 aastat Universumi uudistamist Eestis", Eesti Teaduste Akadeemia, Tallinn, 25.03.2009) – E. Tempel.

200 aastat astronoomiat Eestis (Kukkuv Õun, Raadio Kuku, 29.03.2009) – L. Leedjärv.

Interakteeruvatest kaksiktähtedest (Tartu Tähetorni Astronoomiaring, 31.03.2009) – A. Puss.

Venemaa kosmonautika ja kosmosetehnoloogia – minevikusaladusi ja uusi suundumusi (Tartu Tähetorni Astronoomiaring, 07.04.2009) – U. Veismann.

Ülevaade teleskoopide arengust (Kuku Raadio, 09.04.2009) – K. Annuk.

Sissejuhatus ja kommentaar OoofilmiõhtuooO filmile "100 greatest discoveries: astronomy" (Tartu, 14.04.2009) – E. Tempel.

Astronoomiast, Rahvusvahelisest Astronoomia Aastast ja elust üldse (Külalise Tund, Pereraadio, 15.04.2009) – L. Leedjärv.

Ohtlikud naabrid (Tallinna Reaalkooli teaduspäev, Tallinn, 16.04.2009) – T. Viik.

Astronoomia: tähtedest galaktikateni (Võnnu Keskkool, 16.04.2009) – E. Tempel.

Astronoomia: tähtedest galaktikateni (Türi Majandusgümnaasium, 17.04.2009) – E. Tempel.

Sümbiootilised kaksiktähed (Tartu Tähetorni Astronoomiaring, 21.04.2009) – M. Burmeister.

Päikese aktiivsusest (Seitsmesed Uudised, TV3, 26.04.2009) – K. Annuk.

Taevased kaksikud (Kesköö programm, Vikerraadio, 08.05.2009) – L. Leedjärv, A. Puss.

Universumi struktuur (Kärdla Gümnaasium, Hiiumaa, 08.05.2009) – J. Einasto.

Universumi struktuur ja evolutsioon (Ahtme Gümnaasium, Ahtme, 14.05.2009) – J. Einasto.

Gustav Naan 90 (Tartu Tähetorni Astronoomiaring, 19.05.2009) – T. Viik (kaasettekanne).

Ohtlikud naabrid (TTÜ Virumaa kolledži astronoomiapäev, Kohtla-Järve, 23.05.2009) – T. Viik.

Tähed tumedas Universumis (TTÜ Virumaa kolledži astronoomiapäev, Kohtla-Järve, 23.05.2009) – L. Leedjärv.

Maa ja tema asukad Päikese paistel (TTÜ Virumaa kolledži astronoomiapäev, Kohtla-Järve, 23.05.2009) – K. Eerme.

Ohtlikud naabrid (Vihasoo küla teaduspäev, Vihasoo, 31.05.2009) – T. Viik.

Universumi algusest tänapäevani (Euroülikool, Tõravere, 16.06.2009) – E. Tempel.

Astronoomia Eestis (Terevisioon, ETV, 19.06.2009) – J. Einasto.

Päikese ja Maa suhetest (Füüsikaõpetajate suvekool, Nõo, 25.06.2009) – K. Eerme.

Teleskoopide uusimatest arengutest (Füüsikaõpetajate suvekool, Nõo, 25.06.2009) – K. Annuk.

Einasto ja tema järglased (Astronoomiahuviliste XIV üle-Eestiline kokkutulek, Tõravere, 14.08.2008) – P. Tenjes.

Atmosfäär ja selle seire (Astronoomiahuviliste XIV üle-Eestiline kokkutulek, Tõravere, 14.08.2008) – K. Eerme.

XIX sajandi astronoomia Eestis (Astronoomiahuviliste XIV üle-Eestiline kokkutulek, Tõravere, 14.08.2008) – T. Viik.

Maapinna kaugseirest (Astronoomiahuviliste XIV üle-Eestiline kokkutulek, Tõravere, 14.08.2008) – T. Nilson.

E.J. Öpiku ja G. Kuzmini elust (Astronoomiahuviliste XIV üle-Eestiline kokkutulek, Tõravere, 14.08.2008) – J. Einasto.

Epsilon Aurigae (Astronoomiahuviliste XIV üle-Eestiline kokkutulek, Tõravere, 15.08.2009) – T. Eenmäe.

Amatöörteleskoopide põhimõisted ja -tõed (Astronoomiahuviliste XIV üle-Eestiline kokkutulek, Tõravere, 15.08.2009) – T. Eenmäe.

Optilise teleskoobi ajaloost ja arengust (Astronoomiahuviliste XIV üle-Eestiline kokkutulek, 16.08.2009) – A. Tamm.

Leiutised ja astronoomia (Eesti noorte leiutajate suvekool, Rõuge, 18.08.2009) – E. Tempel.

Arvutijoonistuste võistluse tutvustus (Kuku Raadio, 31.08.2009) – K. Annuk.

Ohtlikud naabrid (Pärnu Sütevaka Humanitaargümnaasiumi koolilaager, Pärlselja, 31.08.2009) – T. Viik.

Taevakehad, tähtkujud ja sodiaagimärgid: teaduslik uurimine ning manipuleerimine (Teaduskommunikatsiooni konverents 2009. Täheteadus – astroloogiast astronoomi pilgu läbi, Tartu, 24.09.2009) – A. Puss.

Planeedisüsteem kui nõrga müra allikas (Teaduskommunikatsiooni konverents 2009. Täheteadus – astroloogiast astronoomi pilgu läbi, Tartu, 24.09.2009) – J. Pelt.

Optilise teleskoobi ajaloost ja arengust (Tartu Tähetorni Astronoomiaring, 06.10.2009) – A. Tamm.

The View from the Center of the Universe (suuline kommentaar filmile) ("OoofilmiõhtuooO", Tartu, 15.10.2009) – T. Viik.

Planeedid, tähed, galaktikad – esinemine "Galileo ööde" raames (Otepää Kultuurikeskus, 22.10.2009) – T. Tuvikene, E. Tempel.

Planeedid, tähed, galaktikad – esinemine "Galileo ööde" raames (Rannu Rahvamaja, 23.10.2009) – T. Tuvikene, E. Tempel.

Räägime ilmast (Nõo Päevakeskus, 27.10.2009) – V. Russak.

Messier maraton (Tartu Tähetorni Astronoomiaring, 17.11.2009) – A. Puss.

Intervjuu (Kuku raadio, 19.11.2009) – A. Puss.

Intervjuu (ETV, Tähelaev, Tallinn, 22.11.2009) – J. Einasto.

Looduseuurijate seltsi majast ja seltsi tegevusest (Koolitus- ja nõustamiskeskuse "HARED" seminar, Tartu, 24.11.2009) – T. Viik.

Pierre Louis Moreau de Maupertuis – korsaari pojast nii Berliini kui Pariisi akadeemiate presidendiks (Tartu Tähetorni Astronoomiaring, 01.12.2009) – T. Viik.

Tähed tumedas Universumis (Kullamaa Keskkool, 04.12.2009) – L. Leedjärv.

Tähetolmu saadikud Universumit uudistamas (Eesti Kirjandusmuuseum, Kreutzwaldi päevad, Tartu, 17.12.2009) – L. Leedjärv.

Tänapäeva astronoomia (Eesti Kirjandusmuuseum, Kreutzwaldi päevad, Tartu, 18.12.2009) – J. Einasto.

Gammasähvatused (Tallinna Reaalkooli liitklasside päev, 23.12.2009) – T. Viik.

Kokkuvõte rahvusvahelisest astronoomia aastast (Huvitaja, Vikerraadio, 28.12.2009) – K. Annuk.

Maailma sünd ja areng (Tartu Ülikooli Kliinikum, Tartu, 30.12.2009) – J. Einasto.

11.3 Public observing nights and other activities in the framework of IYA2009 Avalikud vaatlusõhtud ja muu tegevus seoses RAA2009

Avalikud vaatlusõhtud (Tõravere, 05.02.–08.02.2009) – K. Annuk, I. Kolka, M. Ruusalepp, E. Tempel.

Avalikud vaatlusõhtud (Tõravere, 05.03.–08.03.2009) – M. Ruusalepp, E. Tempel, T. Tuvikene, J. Vennik.

Avalikud vaatlusõhtud (Tõravere, 02.04.–08.04.2009) – K. Annuk, I. Kolka, L. Leedjärv, A. Puss, M. Ruusalepp, E. Tempel, T. Tuvikene.

Teaduskeskus AHHAA vaatlusõhtu "100 tundi astronoomiat" (Sindi Gümnaasiumi staadion, 02.04.2009) – A. Puss.

Teaduskeskus AHHAA vaatlusõhtu "100 tundi astronoomiat" (Valga, 03.04.2009) – T. Eenmäe.

Teaduskeskus AHHAA vaatlusõhtu "100 tundi astronoomiat" (Viljandi, 04.04.2009) – A. Hirv, T. Tuvikene.

Teaduskeskus AHHAA vaatlusõhtu "100 tundi astronoomiat" (Rakvere, 05.04.2009) – T. Eenmäe.

Ekskursioonide läbiviimine (Tartu Tähetornis rahvusvahelise muinsuskaitsepäeva puhul, 18.04.2009) – A. Puss.

Avalikud vaatlusõhtud (Tõravere, 01.05.–03.05.2009) – K. Annuk, I. Kolka, M. Ruusalepp, E. Tempel, J. Vennik.

Teaduskeskus AHHAA vaatlusõhtu (Saverna Põhikool, 02.05.2009) – A. Puss, T. Tuvikene.

Vabaõhu-planetaariumietendused (ESÜ ja EGL suurlaager "Tähemets 2009", Tagametsa, 13.07.–16.07.2009) – A. Puss, E. Tempel.

Teadlaste ÖÖ vaatlusõhtud (Tõravere, Tartu ja Narva, 25.09.2009) – K. Annuk, T. Eenmäe, A. Hirv, A. Puss, M. Ruusalepp, T. Sepp, T. Tuvikene.

Avalikud vaatlusõhtud "Galileo ööd" (Tõravere, 22.10.–24.10.2009) – K. Annuk, A. Puss, M. Ruusalepp.

Vaatlusõhtu "Galileo ööd" (Otepää Kultuurikeskus, 22.10.2009) – T. Tuvikene, E. Tempel.

Vaatlusõhtu "Galileo ööd" (Rannu Rahvamaja, 23.10.2009) – T. Tuvikene, E. Tempel.

Astronoomia.ee veebilehe loomine ja arendamine – T. Tuvikene.

"Astronoomiapildi" rubriigis 46 Eestiga seotud nädala pildi toimetamine – T. Tuvikene.

142 lühisõnumit astronoomiast – T. Tuvikene.

Astronoomiliste piltide näitused aastal 2009:

Tartu Ülikooli Raamatukogu, Tartu: 01.02.–28.02.2009.
Tallinna Ülikool, Tallinn: 16.03.–31.03.2009.
Tartu Kaubamaja, Tartu: 01.04.–30.04.2009.
Eesti Rahvusraamatukogu, Tallinn: 12.06.–01.07.2009.
SPA Estonia, Pärnu: 07.07.–26.08.2009.
Tartu Ülikooli Narva Kolledž, Narva: 01.09.–30.09.2009.
Võrumaa Muuseum, Võru: 06.10.–15.11.2009.
Eesti Kirjandusmuuseum, Tartu: 17.11.–31.12.2009.

Exhibition of astronomical photos in Võru. Astronoomiliste piltide näitus Võrus.

Kooliõpilastele korraldati seoses rahvusvahelise astronoomia aastaga mitu võistlust. 2009. aasta kevadel (tähtajaga 10. mai) toimus joonistuste võistlus. Kolmes erinevas vanuseklassis saabus kokku üle 200 pildi. Samaks ajaks oli välja kuulutatud ka esseede ja lühiuurimuste konkurss, kuid vähese osavõtu tõttu sai seda edasi pikendatud sügiseni. Paraku jäi ka sügisel osavõtt üsnagi kesiseks.

Koos EENetiga organiseeriti sügisel (1. septembrist kuni 15. novembrini) arvutijoonistuste võistlus.siin Siis oli osavõtt hästi aktiivne ja neljas vanusegrupis saabus kokku üle 5200 joonistuse.

Kõikidele võistluste parimatele osalejatele anti väärilised auhinnad ja diplomid. Joonistuste võistluste parimatest piltidest koostati rändnäitused. Kevadise võistluse parimad tööd olid 2009. aasta novembris väljas Tartu Kaubamajas ja arvutijoonistuste 24 parimat pilti võis näha 2010. aasta jaanuaris Riigikogus.

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

11.4.1 Ph.D. theses Doktoritööd

A. Aret: *Evolutionary Separation of Mercury Isotopes in Atmospheres of Chemically Peculiar Stars. Elavhõbeda isotoopide lahknemiskulg keemiliselt pekuliaarsete tähtede atmosfäärides,* Ph.D. Thesis, University of Tartu.
Defence Kaitsmine: 05.06.2009.
Supervisor Juhendaja: A. Sapar (Tartu Observatory).
Opponents Oponendid: J. Kubát (Astronomical Institute of the Academy of Sciences of the Czech Republic, Ondřejov, Czech Republic), G. Tautvaišiené (Institute of Theoretical Physics and Astronomy of Vilnius University, Vilnius, Lithuania).

11.4.2 M.Sc. theses Magistritööd

K. Eerme – *M. Prüssel*: Tõraveres mõõdetud ultraviolettkiirguse spektri sõltuvus pilvisusest Influence of Cloudiness on Ultraviolet Radiation Spectra Measured at Tõravere (M.Sc.), University of Tartu.
Opponent Oponent: U. Veismann.

11.4.3 B.Sc. theses Bakalaureusetööd

I. Kolka – *J. Jänes*: Emissioonijoontega tähtede eristamine kosmoseteleskoobi Gaia objektide hulgas Detection of Emission Line Stars from the Gaia Space Telescope (B.Sc.), University of Tartu.
Kaasjuhendaja Co-supervisor: S. Laur.

J. Pelt – *J. Laur*: Kiirete protsesside fotomeeria nõrkade vaatlusobjektide jaoks Fast Photometry of the Low Light Objects (B.Sc.), University of Tartu.

A. Reinart, K. Alikas – *M. Ligi*: Veekogude seire keskkonna ja turvalisuse programmis Kopernikus Monitoring of Water Bodies in the Framework of GMES/Kopernikus (B.Sc.), University of Tartu.

K. Eerme – *M. Parek*: D-vitamiini sünteesiva ultraviolettkiirguse varieeruvus Tartu-Tõravere meteoroloogiajaamas Variability of D-vitamin Synthesizing UV Radiation at Tartu-Tõravere Meteorological Station (B.Sc.), University of Tartu.
Opponent Oponent: U. Veismann.

I. Ansko, T. Eenmäe – *U. Kvell*: Tartu Ülikooli satelliitside keskus Satellite Communications Center in the University of Tartu (B.Sc.), University of Tartu.

J. Kuusk – *K. Tehvan*: USB liidesega displei välispektromeetrile Display with USB Interface for Field Spectrometer (B.Sc.), University of Tartu.

I. Ansko, T. Eenmäe – *T. Ginter*: Automaatfokuseerija Tartu Observatooriumi teleskoobile Zeiss-600 Automated Focuser for Telescope Zeiss-600 of Tartu Observatory (B.Sc.), University of Tartu .

M. Lang – *A. Palm*: Järvselja ajalooliste metsakorraldusandmete sidumine Eesti põhikaardiga Linking of the Historical Forest Management Data in Järvselja with the Basic Map of Estonia (B.Sc.), Estonian University of Life Sciences.

M. Lang – *O. Zereen*: Nõrkade häirituste tuvastamise võimalused metsades satelliidipiltide põhjal Detection of Weak Disturbances in Forests from Satellite Images (B.Sc.), Estonian University of Life Sciences.

M. Lang – *T. Arumäe*: Lehepinnaindeksi uurimismeetodid Overview of Leaf Area Index Estimation Methods (B.Sc.), Estonian University of Life Sciences.

11.4.4 Refereeing of theses Oponeerimine

K. Eerme – *E. Jakobson*: Atmosfääri niiskussisalduse ajalis-ruumiline muutlikkus Spatial and Temporal Variability of Atmospheric Column Humidity (Ph.D.), University of Tartu.

T. Tuvikene – *J. Laur*: Fast Photometry of the Low Light Objects Kiirete protsesside fotomeetria nõrkade vaatlusobjektide jaoks (B.Sc.), University of Tartu.

12 Staff Koosseis (01.01.2010)

Director / Direktor	Laurits Leedjärv (Ph.D.)
Vice director (management) / Haldusdirektor	Enno Ruusalepp
Project manager / Projektijuht	Tiia Lillemaa

Department of Astrophysics Astrofüüsika osakond

Group of stellar physics Tähefüüsika töörühm

Senior research associate / Vanemteadur	Tõnu Kipper (D.Sc.) (Head of Department / Osakonna juhataja)
Senior research associate / Vanemteadur	Kalju Annuk (Ph.D.)
Senior research associate / Vanemteadur	Tiit Nugis (Ph.D.)
Senior research associate / Vanemteadur	Indrek Kolka (Ph.D.)
Research associate / Teadur	Alar Puss (M.Sc.)
Research associate / Erakorr. teadur	Mari Burmeister (M.Sc.)
Research associate / Erakorr. teadur	Anti Hirv (M.Sc.)
Research associate / Erakorr. teadur	Taavi Tuvikene (M.Sc.)
Research associate / Erakorr. teadur (0.50)	Tõnis Eenmäe (M.Sc.)
Engineer / Insener (0.10)	Tiina Liimets (M.Sc.)

Group of theoretical astrophysics Teoreetilise astrofüüsika töörühm

Senior research associate / Vanemteadur	Arved Sapar (D.Sc., Prof., EAS[1])
Senior research associate / Vanemteadur	Jaan Pelt (Ph.D.)
Senior research associate / Vanemteadur	Tõnu Viik (D.Sc.)
Research associate / Teadur	Anna Aret (Ph.D.)
Research associate / Teadur	Raivo Poolamäe (M.Sc.)
Research associate / Teadur	Lili Sapar (Ph.D.)
Research associate / Teadur (0.50)	Vladislav-Venjamin Pustynski (Ph.D.)
Research associate / Erakorr. teadur (0.50)	Voldemar Harvig (Ph.D.)
Research associate / Erakorr. teadur (0.25)	Indrek Vurm (M.Sc.)

[1]Member of the Estonian Academy of Sciences Eesti Teaduste Akadeemia akadeemik

Group of telescopes Teleskoopide töörühm

Leading electronic engineer / Juhtinsener-elektroonik	Riho Koppel
Maintenance engineer / Hooldusinsener (0.50)	Toivo Kuusk

Department of Cosmology Kosmoloogia osakond

Group of physics of galaxies Galaktikate füüsika töörühm

Senior research associate / Vanemteadur	Urmas Haud (D.Sc.)
Senior research associate / Vanemteadur	Jaan Vennik (Ph.D.)
Senior research associate / Vanemteadur (0.25)	Peeter Tenjes (D.Sc.)
Research associate / Teadur	Antti Tamm (Ph.D.)
Research associate / Erakorr. teadur (0.50)	Valeri Malyuto (Ph.D.)
Research associate / Erakorr. teadur	Elmo Tempel (M.Sc.)

Group of cosmology Kosmoloogia töörühm

Senior research associate / Vanemteadur	Enn Saar (D.Sc.)
	(Head of Department / Osakonna juhataja)
Senior research associate / Vanemteadur	Jaan Einasto (D.Sc., Prof., EAS[1])
Senior research associate / Vanemteadur	Mirt Gramann (Ph.D.)
Senior research associate / Vanemteadur	Maret Einasto (D.Sc.)
Senior research associate / Vanemteadur	Erik Tago (Ph.D.)
Senior research associate / Erakorr. vanemt.	Gert Hütsi (Ph.D.)
Research associate / Teadur	Ivan Suhhonenko (Ph.D.)
Research associate / Erakorr. teadur	Lauri J. Liivamägi (M.Sc.)
Post doctoral associate / Järeldoktor	Margus Saal (Ph.D.)
Engineer / Insener (0.50)	Ingrid Enkvist
Technician / Tehnik (0.70)	Peeter Einasto
Technician / Tehnik (0.30)	Triin Einasto

Group of data communication Andmeside töörühm

Leading engineer / Andmeside juhtinsener	Margus Sisask

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