Contents Sisukord

Eessõna

Üks aasta on jälle ajalooks saanud. Teadustöös ei pruugi ajavahemik 1. jaanuarist 31. detsembrini alati lõpetatud tulemusi anda. Selles ju teaduse võlu ongi, et üks lahendatud küsimus võib püstitada mitu uut. Aga kes siis veel, kui mitte astronoomiaga tegelev uurimisasutus peaks järgima planeedi Maa tiirlemise rütmi. Nii olemegi valmis saanud Aastaraamatu, mis ilmub 16. korda. Nagu eelmiselgi aastal, palume põhjalikuma teadustöö kokkuvõtte lugemiseks eesti keeles pöörduda meie veebilehe *http://www.aai.ee* poole.

Ei ole mõtet üritada eessõna nappides ridades järgneva sajakonna lehekülje sisu kokku võtta, aga mõnda seika tahaks siin korrata küll. Näiteks ei meenu lähiminevikust aastat, mil tervelt kolm noort teadlast Observatooriumist oleksid kaitsnud doktoritöö – tubli, Antti Tamm, Gert Hütsi ja Mait Lang! Tänu võimalusele võtta enamik meiega seotud doktorante ja magistrante tööle osakoormusega teaduritena või inseneridena, jõudis Observatooriumi töötajate arv üle tüki aja taas 70 piirimaile. Loomulikult aitavad noored kaasa ka teadlaste keskmise vanuse vähendamisele. Veidi avardus ka meie rahvusvaheline mõõde: kosmoloogia töörühmas töötab järeldoktorina Evgenii Vasiliev Rostovist, 2007. aasta alguses aga liitus taimkatte seire töörühmaga Miina Rautiainen Helsingist. Gert Hütsi suundus pärast doktoritöö edukat kaitsmist Münchenis järeldoktori kohale Londonis.

Taas olid veidi avaramad võimalused soetada uut teadusaparatuuri, eriti tänu taimkatte uurijate osalemisele Alus- ja Rakendusökoloogia Tippkeskuses. Astronoomid jätkasid vaatlusi Eesti kliima kiuste. 2006. aasta ei toonud veel käegakatsutavaid tulemusi regulaarseks ligipääsuks mõnele paremas kohas asuvale teleskoobile, kuid eeltöö käib – loodetavasti saab väike saar La Palma Kanaaride loodenurgas lähiaastatel mitmetele Eesti astronoomidele (ja eriti noortele) tuttavamaks. Laiemas plaanis teeb rõõmu Eesti valitsuse valmisolek sõlmida rahumeelse kosmosealase koostöö leping Euroopa Kosmoseagentuuriga ESA. Kui leping eeldatavasti 2007. aasta esimesel poolel alla kirjutatakse, saab loodetavasti ka Tartu Observatoorium kaasa aidata selle täitmisele konkreetse sisuga.

2006. aasta tõi peahoonesse Tõraveres soojema õhkkonna – seda eelkõige otsese mõttes. Suvel suurt segadust põhjustanud keskküttesüsteemi ümberehitus näib end igati õigustavat. Suur tänu peainsener Rein Kalbergile ja haldusdirektor Enno Ruusalepale – ja muidugi AS Tanelile, kes selle keerulise töö korralikult ära tegi.

Ees ootab väga tõsine aasta. 2007. aastal tuleb meil taotleda uued sihtfinantseeritavad teadusteemad. Peagi kuulutatakse välja uus teaduse tippkeskuste konkurss. Varem või hiljem hakkavad liikuma eurorahad teaduse infrastruktuuri kaasajastamiseks. Juba on avatud Euroopa Liidu teadusuuringute 7. Raamprogrammi esimesed projektikonkursid. Edukas olla sooviv teadusasutus peab sellistes ettevõtmistes osalema. Loodetavasti on meile toeks ka praegu Riigikogus arutlusel olev Eesti teadus- ja arendustegevuse strateegia "Teadmistepõhine Eesti II".

Soovin kolleegidele visadust, jõudu ja ka parajat hulka õnne, et meie soovid ja eesmärgid täituksid.

Direktor

Tõraveres
veebruar 2007

Foreword

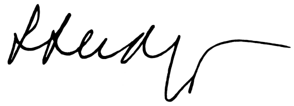
The year 2006 has become an history. The time interval from January 1 to December 31 should not necessarily yield finalized results in research work. Fascination of science often lies in an endless chain of unanswered questions. However, it is just appropriate for an astronomical research institution to follow the rhythm determined by revolving of the Earth about the Sun. Thus, the 16th issue of the Annual Report of the Tartu Observatory is in the hands of the readers.

It is useless to attempt to summarize content of the following one hundred or more pages in a few rows here. Nevertheless, some important issues should be pointed out. For example, one cannot remember another such a good year from the nearest past when three young scientists from the Observatory defended their Ph.D. thesis – well done, Antti Tamm, Gert Hütsi and Mait Lang! We were able to employ most of our Ph.D. and M.Sc. students as part-time research associates or engineers, and so, the number of the people employed by the Tartu Observatory reached 70 after a long time. Needless to say, those young people help to reduce the mean age of our scientists. Our international dimension widened further: a post-doc research associate Evgenii Vasiliev from Rostov works in the group of cosmology from April, 2006. Starting from the beginning of 2007, another post-doc associate Miina Rautiainen from Helsinki joined the group of remote sensing of vegetation. After successful defence of the Ph.D. thesis in Munich, Gert Hütsi moved to a post-doctoral position in London.

We were able to acquire some new scientific instruments, in particular, thanks to the participation in the Centre of Excellence for Basic and Applied Ecology by our group of remote sensing of vegetation. Astronomers continued their observations at Tõravere, in spite of hostile climate in Estonia. Negotiations in order to guarantee a regular access to some telescope in a better climate are underway – hopefully the small *isla de La Palma* in the northwestern corner of Canary islands will be more familiar to several Estonian astronomers during the coming years. In a wider context, it is a pleasure to note that Government of Estonia has revealed will to conclude a framework agreement with the European Space Agency for space cooperation for peaceful purposes. Should the agreement be signed in the first half of 2007 as expected, our Observatory would hopefully be one of the institutions which would fill the agreement with a real content.

The year 2006 brought a warmer atmosphere into the main building of the Observatory – in the sense that central heating system was completely renovated. Although this process created quite a mess during the whole summer, the results are rewarding. Many thanks to chief engineer Rein Kalberg and management vice-director Enno Ruusalepp for organizing and to Tanel Ltd. for performing this work.

The forthcoming year 2007 will be full of hard work. We need to apply for new target-financed projects. We should participate in a new competition for the Centres of Excellence. Most likely, the rules for applying and using the European Structural Funds for renovation of research infrastructures will be announced soon. First calls for proposals in the European 7th Framework Programme are opened. The Parliament of Estonia is discussing a new strategy for R & D activities "Knowledge-based Estonia II". Let's hope that Tartu Observatory would benefit from all those developments.



Direktor

Tõraveres
veebruar 2007

1 Ülevaade

1.1 Uurimisteemad ja grandid

2006. aastal jätkus Tartu Observatooriumis kolme sihtfinantseeritava teadusteema täitmine (1 kEEK = 1000 EEK = 63.9 EUR):

- Struktuuride areng Universumis kaugest minevikust tänapäevani (teema juht J. Einasto) – 2300 kEEK,
- Tähtede ehitus, keemiline koostis ja evolutsioon (teema juht T. Kipper) – 3138 kEEK,
- Eesti ning Balti regiooni keskkonna optilise kaugseire alused (teema juht A. Kuusk) – 2510 kEEK.

Lisaks rahastas Sihtasutus Eesti Teadusfond 14 granti:

1. Grant 5347: M. Gramann – Superparvede, parvede ja galaktikate dünaamiline evolutsioon Universumis – 73.4 kEEK.
2. Grant 5348: U. Veismann – Atmosfääri optiliste parameetrite mõju Päikese ultraviolettkiirgusele maapinnal – 85 kEEK.
3. Grant 5760: I. Pustylnik – Füüsikalised protsessid ja evolutsioonilised trendid kaksiksüsteemides valgete kääbustähtede formeerumise varajases staadiumis – 62 kEEK.
4. Grant 6100: A. Kuusk – Kiirgusenergia hajumine ja neeldumine looduslikes ja kultiveeritud taimkatetes – 124 kEEK.
5. Grant 6104: E. Saar – Suuremastaabilise struktuuri täppiskosmoloogia – 220 kEEK.
6. Grant 6105: A.-E. Sapar – Täheatmosfääride ja tähetuule ehitus ja spektrid; füüsikalised protsessid neis – 140 kEEK.
7. Grant 6106: J. Vennik – Galaktikate evolutsioon gruppides – 137 kEEK.
8. Grant 6810: I. Kolka – Suure kiirgusvõimsusega kaugelearenenud tähed kosmoseteleskoobi Gaia objektidena – 141 kEEK.
9. Grant 6812: M. Mõttus – Hüperspektraalsete ja mitme vaatenurga alt mõõdetud kaugseireandmete kasutamisvõimalused metsa struktuuri hindamiseks – 173.2 kEEK.
10. Grant 6813: J. Pelt – Dispersioonispektrite teooria ja rakendused – 80 kEEK.
11. Grant 6814: A. Reinart – Satelliitkaugseire meetodite arendamine Eesti optiliselt mitmekomponendiliste veekogude uurimiseks – 243 kEEK.
12. Grant 6815: T. Nilson – Eesti metsade produktiivsuse monitooring satelliitkaugseire abil – 200 kEEK.
13. Grant 6845: U. Peterson – Metsaga metsamaa pindala muutused Balti regiooni idaosas alates 1980-ndate aastate keskpaigast kuni aastani 2005, hinnangud Landsat TM satelliidipiltide aegreast - 80 kEEK.

14. V. Russak oli üks põhitäitja TÜ dotsendi H. Ohvrili grandis nr. 5857 (44.8 kEEK Tartu Observatooriumile).

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

Muud projektid ja lepingud:

- Keskkonnaministeeriumi riikliku keskkonnaseire programmi alamprogramm "Eesti maastike muutuste uuringud ja kaugseire" – Keskkonnaministeerium: U. Peterson – 200 kEEK.
- HYRESSA – HYperspectral REmote Sensing in Europe – specific Support Actions – EL 6. raamprogrammi projekt (2006–2008) – Euroopa Komisjon: projekti juht Dr. Ils Reusen, Flemish Institute for Technological Research (VITO); TO koordinaator M. Mõttus – 130.2 kEEK.
- Rootsi Riikliku Kosmosenõukogu grant (2006–2007) "Operatiivsete kaugseire meetodite arendamine Rootsi veekvaliteedi monitooringu toetamiseks": A. Reinart – 39 kSEK ≈65.7 kEEK.
- Eesti rannikumere ja siseveekogude kaugseire meetodite täiustamine – Keskkonnaministeerium: A. Reinart – 40 kEEK.
- Deklareeritud põllupindade kontroll kaugseirevahenditega – Põllumajanduse Registrite ja Informatsiooni Amet: U. Peterson – 40 kEEK.
- Puude ja põõsaste katvus Hiiu ja Pärnu maakonna põllumassiividel – Põllumajanduse Registrite ja Informatsiooni Amet: U. Peterson – 30 kEEK.
- Riikliku programmi "Humanitaar- ja loodusteaduslikud kogud" alamprogramm "Astronoomiliste fotoplaatide digitaliseerimine ja plaatide arhiivi korrastamine" – Haridus- ja Teadusministeerium: K. Annuk – 103.4 kEEK.
- Eeluuring optilise kiirguse täppisradiomeetria rakendusteks Eesti ettevõtetes – Ettevõtluse Arendamise Sihtasutus: A. Reinart, U. Veismann – 185 kEEK (makstakse pärast projekti lõppu aastal 2007).
- Taimkatte seire töörühm osaleb Alus- ja Rakendusökoloogia Tippkeskuses, juhataja Prof. Olevi Kull (Tartu Ülikool, Botaanika ja Ökoloogia Instituut). Selle koostöö raames toetas Ettevõtluse Arendamise Sihtasutus infrapunakaamera ThermaCam SC 3000 ostu summaga 1342.45 kEEK.

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

1.2 Töötajad

Observatooriumi töötajate arv suurenes 2006. aasta jooksul üsna märgatavalt. Peamiselt tänu sihtfinantseerimise mõningale suurenemisele saime enamiku meiega seotud doktorantidest ja magistrantidest võtta tööle 0.25 koormusega teaduritena või inseneridena. 1. veebruaril lisandusid töötajate nimekirja Mari Burmeister, Tõnis Eenmäe, Anti Hirv, Joel Kuusk ja Indrek Vurm, 1. märtsil Krista Alikas ja Kristi Valdmets ning 1. mail Tiina Liimets. Ka Tallinna Tähetorni astronoom Voldemar Harvig on alates 1. märtsist 0.25 koormusega meie tähefüüsika teema täitjate hulgas.

Rõõmustav on märkida, et kolm noort kolleegi kaitsesid 2006. aastal oma doktoritöö: Gert Hütsi Münchenis ning Antti Tamm ja Mait Lang Tartus.

Matti Mõttus töötas esimese poole 2006. aastast järeldoktorina Helsingi Ülikoolis. Omamoodi "vahetusena" töötab 2007. aasta algusest meie Observatooriumis Soome Akadeemia järeldoktor Miina Rautiainen Helsingist. Meie oma baasfinantseerimise arvelt töötab järeldoktorina kosmoloogia erialal Evgenii Vasiliev Rostovist (Venemaa, alates 5. aprillist 2006).

2006. aasta tõi kaasa ka mitmeid kurbi kaotusi. 6. juunil lahkus 68 aasta vanuselt kauaaegne hea kolleeg Mihkel Jõeveer. Muude ülesannete seas oli tema peamiseks tööks viimasel ajal "Tähetorni Kalendri" koostamine ja andmete arvutamine. Ta oli viimase 31 kalendri peatoimetaja.

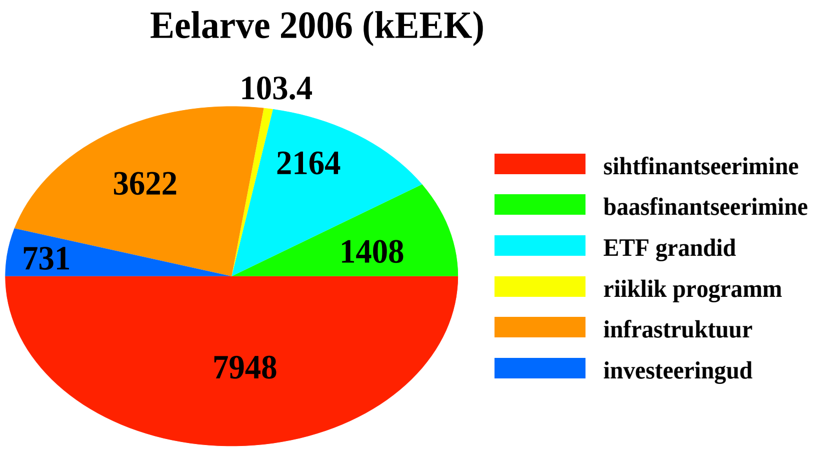
17. novembril saime teate Eesti vanima astronoomi Hugo Raudsaare (83) surmast. Peale selle, et ta oli viimane vaatleja vanas Tartu Tähetornis Toomemäel, oli ka tema mõnda aega "Tähetorni Kalendri" peatoimetaja.

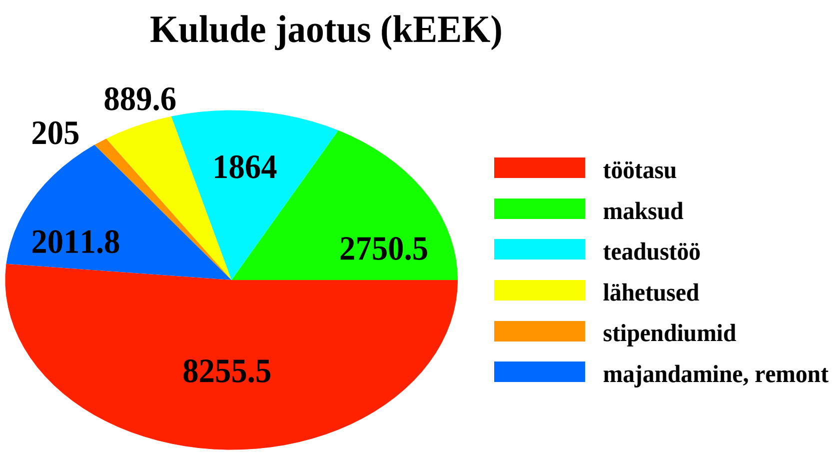
Sügava kurbusega meenutame, et meie hulgast lahkusid ka endised kolleegid Ira Saar (63) 27. veebruaril ja Herbert Niilisk (76) 16. oktoobril.

Kõigi muutuste tulemusena oli 1. jaanuaril 2007 Tartu Observatooriumis tööl 70 inimest, neist 43 vanemteaduri või teadurina ja 7 teadustööd tegeva insenerina.

1.3 Eelarve

Riigieelarvest eraldati Tartu Observatooriumile 2006. aastal 15.976 miljonit krooni (15 976 kEEK). Tulud ja kulud jagunesid järgnevalt:





Lisaks laekus *ca* 1947 kEEK mitmesugustest koostööprojektidest ja lepingutest, mida on nimetatud osas 1.1.

Observatooriumi teadlaste keskmine töötasu 2006. a lõpul oli 11 523 EEK (*ca* 736 EUR).

1.4 Aparatuur ja seadmed

Uus aparatuur:

- Koostöös Alus-ja Rakendusökoloogia Tippkeskusega (Tartu Ülikool) muretses taimkatte seire töörühm firma FLIR Systems infrapunakaamera ThermaCam SC 3000, mis töötab spektripiirkonnas 8–9 μm, temperatuuritundlikkus 20 mK.
- Veekogude kaugseire meetodite arendamiseks täiendati TriOS Optical Sensors komplekti teise hüperspektraalse radiomeetriga RAMSES-ARC-VIS. Selle spektraalsed omadused (piirkond 380–950 nm, lahutusvõime 2 nm) võimaldavad täiustada vee bio-optilisi mudeleid ja kasutada riista satelliitide tulemite kontrolliks ka pidevmõõtmiste režiimis liikuvalt laevalt.
- Firma Carl Zeiss minispektromeetri mooduli MMS-1 (400–1100 nm, 256 kanalit) baasil ehitas J. Kuusk arvutijuhitava lennukispektromeetri, millega mõõdeti Järvselja katseala metsade peegeldusspektreid.
- Astrofüüsikaliste spektraalvaatluste jaoks muretseti uus CCD kaamera Andor Newton DU 970N, millel on 1600$\times$200 pikselit (pikseli suurus 16$\times$16 μm), termoelektriline jahutussüsteem (töötemperatuur –90° C) ja kõrge valgustundlikkus, eriti spektri ultravioletses osas.

Astronoomilised vaatlused jätkusid tavapärasel viisil. 1.5 m teleskoobiga tehti spektraalvaatlusi 54 ööl ning 0.6 m teleskoobiga fotomeetrilisi vaatlusi 8 ööl.

1.5 Teadusnõukogu töö

Tartu Observatooriumi teadusnõukogu on 13-liikmeline. 2006. a selle koosseis ei muutunud. Nõukogu esimees on direktor Laurits Leedjärv ja aseesimees vanemteadur Tõnu Viik. Väljastpoolt Observatooriumi kuuluvad nõukogusse Riigikogu aseesimees akadeemik Ene Ergma ja Tartu Ülikooli professor Rein Rõõm. Haridus- ja Teadusministeeriumi poolt määratud liige on TÜ dotsent Peeter Tenjes.

Teadusnõukogu pidas 10 koosolekut, kuulati järgmisi teaduslikke ettekandeid:

Jaanuar – *T. Kipper*: Iseäraliku muutliku tähe V838 Mon uurimisest.

Veebruar – *U. Peterson*: Väga suure ruumilise lahutusega satelliidipildid metsade kaugseires.

Märts – *A. Sapar*: Kuumade täheatmosfääride ja nende spektrite mudelarvutuste tulemustest ja probleemidest.

Aprill – *T. Viik*: Polariseeritud kiirgus sügaval atmosfääris.

September – *T. Liimets*: V 838 Monocerotis'e fotomeetria ja valguskaja.
– *J. Budenkova*: Metsakooslustes aja jooksul toimunud muutuste hindamine kaugseire ja ruumianalüüsi vahenditega.

November – *U. Veismann, A. Reinart*: Rakendusuuringud optika-radiomeetria ja kaugseire alal.

Detsember – *A. Kuusk*: Metsade peegeldusspektrite mõõtmine satelliidilt ja helikopterilt.

Muid teadusnõukogu tegemisi:

- 13. veebruari koosolekul rääkis Peeter Tenjes õppetöö korralduse uuendustest Tartu Ülikoolis.
- 13. märtsi koosolekul kinnitati lõppenud ETF grantide lõpparuanded.
- 24. märtsil esitati Tõnu Viik Eesti Teadusfondi reaalteaduste ja tehnika ekspertkomisjoni esimehe kandidaadiks ning toetati Toivo Maimetsa kandidatuuri keskkonnateaduste ja eluslooduse ekspertkomisjoni esimehe kohale. Samuti kinnitati O. Okulovi järeldoktori grandi lõpparuanne.
- 17. aprilli koosolekul esitas L. Leedjärv eelmisel aastal eraldatud baasfinantseerimise raha kasutamise aruande.
- 12. juuni koosolekul arutati Tartu Observatooriumi arengukava ja investeeringute plaane. Määrati kindlaks E.J. Öpiku ja J. Rossi nimeliste stipendiumite suurus – 10 000 EEK kumbki.
- 25. septembri koosolekul määrati Ernst Julius Öpik nimeline stipendium TÜ magistrandile Tiina Liimetsale ja Juhan Rossi nimeline stipendium Eesti Maaülikooli doktorandile Julia Budenkovale.
- 16. oktoobri koosolekul kinnitati sihtfinantseeritavate teemade jätkutaotlused.
- 18. detsembri koosolekul esitati riigi teaduspreemia kandidaatideks teadusharu paradigmat ja maailmapilti mõjutava avastuse eest akadeemik Jaan Einasto (kollektiivi juht) ning Maret Einasto, Enn Saar ja Erik Tago.

1.6 Suhted avalikkusega

Ilmselt kõige olulisemaks avalikkusega suhtlemise viisiks on jätkuvalt ekskursioonide vastuvõtmine Tõraveres. 2006. aastal külastas Observatooriumi 221 grupi koosseisus üle 4600 inimese, kes said näha ja katsuda Eesti rahvapärast taevast Lagle Israeli seinapannool, 1.5-meetrist teleskoopi, Stellaariumi väljapanekuid, viibida virtuaalses planetaariumis jne. Giiditööd teevad mitmed astronoomid oma põhitöö kõrvalt, neid juhendab Mare Ruusalepp, kes ka ise sageli ekskursioone vastu võtab.

Taevaste sündmuste ja Observatooriumi tegemiste vastu tunnevad huvi mitmed raadio- ja telekanalid – näiteks Ain Kallis andis 2006. aastal koguni

23 intervjuud, Tõnu Viik 13. Mitmed teadlased esinesid loengutega koolides, firmade üritustel, teaduspäevadel jm, löödi kaasa esmakordselt Eestis läbiviidud "Teadlaste ööl" jne. Täpsem ülevaade on toodud lk. 99–101.

Lisaks sellele, et meie teadlased avaldavad populaarteaduslikke artikleid, huvitub ajakirjandus vahel ka Tartu Observatooriumist endast. Näiteks "Tartu Postimees" pühendas jaanuaris 2006 kaks tervet lehekülge Tõraveres tehtavale.

Tavapärane teadust populariseeriv tegevus jätkus vanas Tartu Tähetornis Toomemäel. Selles lõid aktiivselt kaasa ka meie teadurid Erik Tago ja Tõnis Eenmäe. Traditsioonilisel astronoomiahuviliste üle–Eestilisel kokkutulekul, mis seekord toimus 10.–14. augustini 2006 Mahtras, esinesid meie inimestest ettekannetega Tõnis Eenmäe, Mirt Gramann ja Erik Tago. Mitmed noored teadurid käisid astronoomiahuviliste seltskonnaga Türgis vaatamas 29. märtsil toimunud täielikku päikesevarjutust.

Heino Eelsalu fondi stipendiumi sai Sabine Brauckmann Karl Ernst von Baeri tööde avaldamiseks inglise keeles.

"Tähetorni Kalendrit" 31 aastat toimetanud Mihkel Jõeveer lahkus meie hulgast 6. juunil 2006. Uut peatoimetajat pole me suutnud seni leida, kuid ühiste jõupingutuste tulemusena ilmus 2007. aasta kalender (83. aastakäik) tavapärasel ajal. Uudse väljaandena lasksime trükkida Mare Ruusalepa ja Kalju Annuki koostatud "Tähistaeva Kalender 2007" – loodetavasti saab ka selline värviliste taevapiltidega seinakalender meie traditsiooniliseks väljaandeks.

1.7 Tänuavaldused

Meie teadlased on saanud rahalist või muud toetust paljudelt asutustelt üle maailma. Oleme tänulikud kõigile toetajatele, nende nimed leiate ingliskeelsest osast leheküljel 21.

2 Summary

2.1 Research projects and grants

Most of the finances for basic research in Estonia are channelled through target financed projects. In 2006, research in the framework of three projects was continued (1 kEEK = 1000 EEK = 63.9 EUR):

- Evolution of structure in the Universe from deep past until the present (principal investigator J. Einasto) – 2300 kEEK,
- Structure, chemical composition and evolution of stars (principal investigator T. Kipper) – 3138 kEEK,
- Optical remote sensing of environment in Estonia and Baltic region (principal investigator A. Kuusk) – 2510 kEEK.

In addition, the Estonian Science Foundation financed 14 grant projects from our Observatory:

1. Grant 5347: M. Gramann – Dynamical evolution of superclusters, clusters and galaxies in the Universe – 73.4 kEEK.
2. Grant 5348: U. Veismann – The influence of atmospheric optical parameters on the ground-level solar UV radiation – 85 kEEK.
3. Grant 5760: I. Pustylnik – Physical processes and evolutionary trends in close binary systems during the early stages of white dwarfes formation – 62 kEEK.
4. Grant 6100: A. Kuusk – Scattering and absorption of radiation energy in natural and cultivated vegetation canopies – 124 kEEK.
5. Grant 6104: E. Saar – Precise cosmology of the large scale structure – 220 kEEK.
6. Grant 6105: A.-E. Sapar – Structure and spectra of stellar atmospheres and stellar winds; physical processes in them – 140 kEEK.
7. Grant 6106: J. Vennik – Evolution of galaxies in groups – 137 kEEK.
8. Grant 6810: I. Kolka – Luminous highly evolved stars in the framework of GAIA – 141 kEEK.
9. Grant 6812: M. Mõttus – Applicability of hyperspectral and multiangular remotely sensed data for estimating forest structure – 173.2 kEEK.
10. Grant 6813: J. Pelt – Theory and applications of dispersion spectra – 80 kEEK.
11. Grant 6814: A. Reinart – Development of the remote sensing methods according to the specific conditions of Estonian optically multicomponental waters – 243 kEEK.
12. Grant 6815: T. Nilson – Monitoring the productivity of Estonian forests by satellite remote sensing – 200 kEEK.

13. Grant 6845: U. Peterson – Rates and patterns of forest cover change from mid-1980s till 2005 in the Eastern Baltic region, evaluated with multitemporal Landsat imagery – 80 kEEK.
14. V. Russak participated in the grant 5857 led by H. Ohvril from Tartu University (44.8 kEEK to Tartu Observatory).

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

Some other projects and contracts:

- National programme of environmental monitoring, subprogramme "Remote sensing and studies on change of Estonian landscapes" – Ministry of Environment: U. Peterson – 200 kEEK.
- HYRESSA – HYperspectral REmote Sensing in Europe – specific Support Actions (A EU 6th Framework project) (2006–2008) – European Commission: Project leader Dr. Ils Reusen, Flemish Institute for Technological Research (VITO), our coordinator M. Mõttus – 130.2 kEEK.
- Operationalisation of remote sensing methods to support Swedish water quality monitoring organizations (2006–2007) – Swedish National Space Board, Sweden: A. Reinart – 39 kSEK $\approx$ 65.7 kEEK.
- Remote sensing of coastal and inland waters – Ministry of Environment: A. Reinart – 40 kEEK.
- Checking of declared agricultural lands with remote sensing methods – Estonian Agricultural Registers and Information Board: U. Peterson – 40 kEEK.
- Crown cover of shrubs and trees on agricultural lands in Hiiu and Pärnu counties – Estonian Agricultural Registers and Information Board: U. Peterson – 30 kEEK.
- National programme for preserving collections in humanities and natural sciences, subprogramme "Digitalizing and archiving astronomical photographic plates" – Ministry of Education and Research: K. Annuk – 103.4 kEEK.
- Preliminary study of applications of optical radiometry in Estonian enterprises and institutions (September 2006 – February 2007) – Enterprise Estonia: A. Reinart, U. Veismann – 185 kEEK (to be paid in 2007).
- The group of sensing of vegetation belongs to the Centre of Excellence for Basic and Applied Ecology, headed by Prof. Olevi Kull, Tartu University, Institute of Botany and Ecology. In the framework of this cooperation, purchase of a high precision infrared camera ThermaCam SC3000 was supported by the Enterprise Estonia in the amount of 1342.45 kEEK.

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

2.2 Staff

The number of people employed by the Observatory increased quite significantly during 2006. Thanks to some increase in the target financing, we could employ most of young Ph.D. and M.Sc. students as part-time (0.25) research associates or engineers. Among them are Mari Burmeister, Tõnis Eenmäe, Anti Hirv, Joel Kuusk, Indrek Vurm (all starting from February 1), Krista Alikas, Kristi Valdmets (from March 1), and Tiina Liimets (from May 1). In addition, Voldemar Harvig from Tallinn Observatory was also employed as a part-time research associate from March 1.

It is also pleasure to state that three young researchers from our Observatory defended their Ph.D. thesis in 2006: Gert Hütsi in Munich, Antti Tamm and Mait Lang in Tartu.

Matti Mõttus worked as a post-doctoral associate in the University of Helsinki from January 1 to June 30, 2006. As a kind of ”exchange”, post-doctoral associate Miina Rautiainen from Helsinki started her work at our Observatory in January 2007 (in the group of remote sensing of vegetation). Another post-doctoral associate from Rostov (Russia) Evgenii Vasiliev was employed on April 5, 2006 into the group of cosmology.

On the other hand, we have to mention several sad losses in 2006. On June 6, our good colleague Mihkel Jõeveer passed away in the age of 68. Among others, one of his main tasks was computing and compiling the Calendar of the Observatory. He was an editor-in-chief for 31 issues of the Calendar.

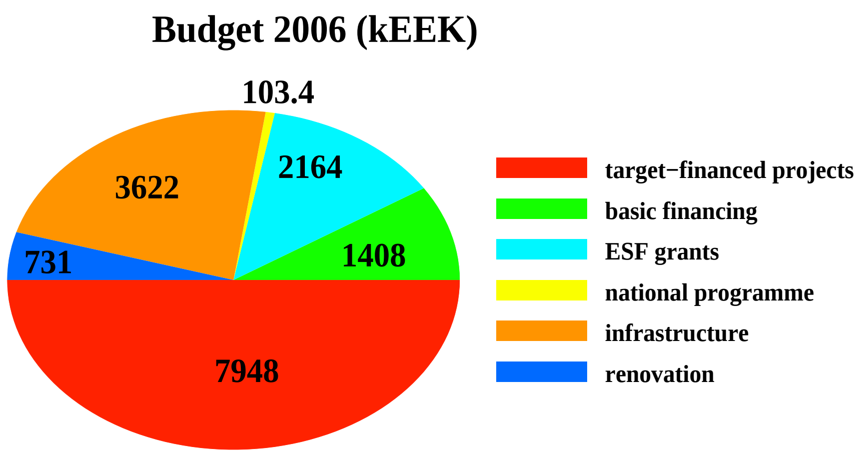
On November 17, we heard about the death of the oldest Estonian astronomer Hugo Raudsaar (83). Besides being the main observer in the Old Observatory in Tartu, he also served as an editor-in-chief of the Calendar of the Observatory for some time.

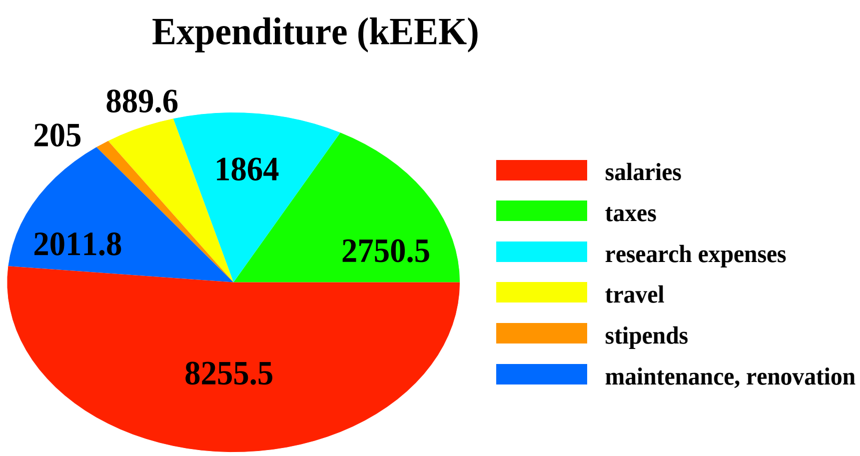
With a deep regret, we note passing away of our former colleagues Ira Saar (63) on February 27, and Herbert Niilisk (76) on October 16.

As a result of all the changes, the number of people employed by the Tartu Observatory was 70 on January 1, 2007. Of them, 43 are on the position of researchers and 7 on that of research engineers.

2.3 Budget

The total amount allocated from the state budget directly to the Observatory was 15 976 kEEK and it was divided as follows:





In addition, about 1947 kEEK from contracts with several organizations were allocated to the Observatory.

The mean monthly salary of researchers was approximately 11 523 EEK (736 EUR) by the end of 2006.

2.4 Instruments and facilities

- In collaboration with the Centre of Excellence for Basic and Applied Ecology, the group of sensing of vegetation purchased a high precision infrared camera ThermaCam SC 3000 (FLIR Systems). The camera works in the spectral range 8–9 μm, sensitivity 20 mK.
- To complement TriOS Optical Sensors measurement system, a second underwater hyperspectral radiometer RAMSES-ARC-VIS was obtained. Its spectral characteristics (range 380–950 nm, resolution 2 nm) enables to develop bio-optical models of water and use the instrument for validation of ocean colour satellite products also during continued measurements from a moving ship.
- Using the minispectrometer module MMS-1 by Carl Zeiss (400–1100 nm, 256 channels) J. Kuusk designed an airborne spectrometer which was used for the measurements of forest reflectance spectra at Järvselja, Estonia.
- A new CCD camera Andor Newton DU 970N for astrospectroscopical observations was purchased. Its main characteristics are 1600$\times$200 pixels (pixel size 16$\times$16 μm), working temperature –90° C achieved by thermoelectrical cooling, and high sensitivity, especially in the ultraviolet spectral region.

Astronomical observations were continued as usually. The 1.5 m telescope was used for spectroscopic observations during 54 nights, and the 0.6 m telescope for photometric observations during 8 nights.

2.5 Scientific Council

Tartu Observatory has a Scientific Council consisting of 13 members. There were no changes in the content of the Council during 2006. 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, vice-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 2006. The following scientific reports were presented:

January – *T. Kipper*: On the studies of the peculiar variable V838 Mon.

February – *U. Peterson*: Extremely high resolution satellite images in the remote sensing of forests.

March – *A.-E. Sapar*: Some results and problems in calculations of model atmospheres for hot stars and their spectra.

April – *T. Viik*: Polarized radiation deep in an atmosphere.

September – *T. Liimets*: Photometry and light echo of the peculiar star V838 Mon.

– *J. Budenkova*: Estimating temporal variations in forest canopies by the means of remote sensing and spatial analysis.

November – *U. Veismann, A. Reinart*: Application studies in optical radiometry and remote sensing.

December – *A. Kuusk*: Measuring reflectance spectra of forests from satellites and from helicopter.

Some other activities of the Council:

- On February 13, Peeter Tenjes informed the Council about alterations in study regulations in the Tartu University.
- On March 13, final reports of the grants from the Estonian Science Foundation were approved.
- On March 24, Tõnu Viik was proposed as a candidate for the post of the Chairman of the Expert Commission for Physical Sciences and Engineering at the Estonian Science Foundation. Final report of the post-doc grant by O. Okulov was also approved.
- On April 17, L. Leedjärv presented a report on the use of basic financing in 2005.
- On June 12, development plan and investment priorities of the Observatory were discussed and approved. At the same meeting, it was decided that the Ernst Julius Öpik and Juhan Ross fellowship in 2006 will be 10 000 EEK both.
- On September 25, the Ernst Julius Öpik fellowship (10 000 EEK) was awarded to the M.Sc. student of Tartu University Tiina Liimets. The Juhan Ross fellowship (10 000 EEK) was awarded to the Ph.D. student Julia Budenkova from the Estonian University of Life Sciences.
- On October 16, applications for continuation of the target-financed projects were discussed and approved.
- On December 18, Academician Jaan Einasto (group leader), Maret Einasto, Enn Saar and Erik Tago were proposed as nominees for the National Science Prize.

2.6 Public relations

One of the main forms of our public relations are excursions to the site of the Observatory at Tõravere. In 2006, more than 4600 people in 221 groups visited the Observatory. They all could see and touch Estonian ethnographic sky on the stony mosaic by Lagle Israel, the 1.5-meter telescope, expositions in the Stellaarium, enjoy starry sky in the virtual planetarium etc. Several our astronomers guide the excursions in addition to their main job. Mare

Ruusalepp coordinates the work of guides, and often guides the excursions herself.

Several radio and TV channels are interested in heavenly events and in the activities of the Observatory – for example, Ain Kallis was interviewed 23 times and Tõnu Viik 13 times in 2006! Our scientists gave lectures in schools, in companies, on public science days etc. The European Reserchers' night was celebrated in Estonia for the first time – needless to say that our astronomers and especially students participated in this event actively.

We wrote popular scientific papers as usually. In addition, some newspapers and magazines published reportages about Tartu Observatory. For example, the "Tartu Postimees" newspaper devoted two full pages to our activities in January 2006.

Popularizing of astronomy continued in The Old Observatory in Tartu as usually, with active participation of our researchers Erik Tago and Tõnis Eenmäe. Traditional annual meeting of Estonian amateur astronomers took place at Mahtra, from August 10 to 14, 2006. Among others, Tõnis Eenmäe, Mirt Gramann and Erik Tago gave lectures there. Some of our researcers travelled to Turkey to watch the total solar eclipse on March 29, 2006.

The fellowship of the Heino Eelsalu Foundation was awarded to Sabine Brankmann for translating papers by famous biologist Karl Ernst von Baer (1792–1876) into English.

Mihkel Jõeveer, who was the editor-in-chief of the Calendar of the Observatory for 31 years, passed away on June 6, 2006. We have not been able to find a new editor-in-chief yet. However, thanks to the efforts by many colleagues, the Calendar for 2007 was published in time. In addition, we published another calendar – "The Calendar of Starry Sky 2007", compiled by Mare Ruusalepp and Kalju Annuk. This calendar contains nice colour photographs, and hopefully will also be our traditional publication.

2.7 Acknowledgements

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

- Astronomical Institute of the Slovak Academy of Sciences
- ASTRONET (EC FP6 project)
- Astrophysikalisches Institut Potsdam
- Enterprise Estonia
- Estonian Academy of Sciences
- Estonian Meteorological and Hydrological Institute
- Estonian Ministry of Education and Research
- Estonian Ministry of Environment
- Estonian Science Foundation

- Euro–Asian Astronomical Society
- European Astronomical Society
- European Commission
- European Southern Observatory
- European Space Agency
- GeoBiosphere Science Centre of Lund University
- Helsinki University
- International Astronomical Union
- Institute of Environmental Physics, Tartu University
- Institute of Limnology, Uppsala University
- Max-Planck Institut für Astrophysik
- National Air and Space Museum, Washington, USA
- Observatoir Astronomie, Universitat de València
- Ondřejov Observatory
- OPTICON (EC FP6 project)
- Oulu University
- Pakker Avio, Tartu
- SIRA Technology Ltd
- Slovak Academy of Sciences
- Sternberg Astronomical Institute, Moscow
- Swedish National Space Board
- Tartu University
- University of Aveiro
- University College London
- World Radiation Center
- Võrtsjärv Centre for Limnology, Estonian University of Life Sciences

3 Evolution of structure in the Universe from deep past until the present Struktuuride areng Universumis kaugest minevikust tänapäevani

Universumit kõige suuremates mastaapides käsitlev kosmoloogia on teatud mõttes ajalooteadus, mis uurib, milline oli Universum miljardeid aastaid tagasi. Viimaste aastate suured taevaülevaated – näiteks 2dFGRS (kahekraadi-välja galaktikate punanihete ülevaade) ja SDSS (Sloani digitaalne taevaülevaade) – näitavad meile järjest suuremaid osi järjest nooremast Universumist. Nende ülevaadete avalikustatud tulemustel baseeruvad suuresti ka meie kosmoloogide tegemised.

Alustagem aga Gert Hütsi doktoritööst, milles ta käsitles kosmilist heli ehk akustilistel sagedustel toimuvaid barüonvõnkumisi. Need akustilised lained, mis levisid väga varases Universumis kiirgusdominantsel epohhil (kuni ajani ca 380 000 aastat pärast Suurt Pauku), jätavad jälgi nii praegu vaadeldavasse reliktkiirgusesse kui galaktikate jaotusesse. Töös õnnestus leida reliktkiirgusest rekordilised seitse maksimumi ning sellega kinnitada barüonvõnkumiste harmoonilisust ja sellest tulenevat inflatsiooniteooria õigsust.

Galaktikate korrelatsioonifunktsiooni omadused suurte galaktikavaheliste kauguste puhul põhimõtteliselt klapivad akustilistest võnkumistest saadud tulemustega, kuid leitud suure amplituudiga võnkumised suurtel vahekaugustel nõuavad ilmselt standardse inflatsiooniteooria täiendamist uut tüüpi häiritustega.

Uuriti galaktikate tihedusväljade morfoloogiat: väga suurtel skaaladel (ca 40 Mpc) läheneb galaktikate jaotus Gaussi jaotusele. Teine galaktikajaotuse morfoloogiaga seotud töö oli galaktikafilamentide automaatse leidmise algoritmi häälestamine. Filamentide kirjeldusfunktsioonide otsinguid viisid huvitavale analoogiale vihmaussiurgude statistikaga.

Jätkus 2dFGRS ja SDSS ülevaadetest saadud galaktikate superparvede uurimine. Avaldati vaadeldud superparvede kataloogid ja koostati mudelsuperparvede kataloogid, kasutades Millenniumi projekti numbrilisi kosmoloogilisi struktuurimudeleid. Võrreldi vaadeldud ja modelleeritud superparvede omadusi. Osutus, et kõige olulisem erinevus vaatluste ja mudelite vahel seisneb superparvede kordsuses: vaatluslike superparvede hulgas on ligi kümme korda rohkem eriti massiivseid (heledaid) superparvi kui modelleeritud superparvede hulgas. Selle erinevuse põhjus ei ole veel selge.

Algas kõige rikkamate superparvede morfoloogia uurimine Minkowski funktsionaalide ja kujuleidjate abil. Esialgu võib öelda, et vaadeldavatel superparvedel on kõigil tüüpiline morfoloogiline signatuur, mida saab modelleerida lihtsa mitmelihargneva filamendi abil.

Uuriti galaktikate vastasmõjusid väikestes tihedates galaktikarühmades: leiti olulisi loodelisi häiritusi eelkõige galaktikate ulatuslikes gaashalodes, ent nõrgemaid häiritusi ka täheketastes.

Doktoriväitekirja kaitses ka Antti Tamm. Selle töö jätkuna saadi 22 kauge ketasgalaktika (punanihetel $0.5 < z < 2.6$ ehk ajas kuni 10 miljardit aastat tagasi) heleduse ja värvuste jaotused. Leiti, et punanihetest $z = 1$ kuni praeguseni (st viimase 6 miljardi aasta jooksul) ei ole galaktikate tähelise aine mass-heleduse suhete ning tumeda aine tsentraalse tiheduse osas märgatavat arengut toimunud. Kaugemad galaktikad on aga oluliselt väiksemad ja sinisemad (tugevama tähetekkega). Kaugete galaktikate kõrval uuriti ka lähedasi galaktikaid, jätkates lähedaste galaktikate detailsete hüdrodünaamiliste mudelite arendamist.

Alustati tumeda aine ruumtiheduse jaotuse uurimist galaktikates, eriti galaktikate keskosades. Kuna kõige täpsemad fotomeetrilised, spektroskoopilised ja kinemaatilised vaatlusandmed on olemas lähedalasuva Andromeda galaktika kohta, siis valitigi see esimeseks objektiks. Tulemused osutusid üllatuslikeks: vaatlustest harilikult leitud isotermilise jaotuse asemel andis parema kooskõla tsentri suunas järsult kasvav nn NFW tiheduse jaotus.

Jätkus neutraalse vesiniku jaotuse uurimine meie Galaktikas. Muuhulgas selgus, et lisaks traditsioonilisele massiivsele kroonile võib osa varjatud ainest olla koondunud kettakujulisse allsüsteemi, mis sisaldab umbes $R \sim 15$ kpc raadiusega rõngasstruktuuri.

Et võrrelda harilikke tumeainet kirjeldavat kosmoloogilise struktuuri arengu mudeleid vaatlustega, alustati galaktikate tekke modelleerimist tumeda aine halodes. Galaktikate tekke uurimisega haakub ka Evgenii Vasilievi, meie Rostovi Ülikoolist tulnud järeldoktori uurimisteema, pimeda aja lõpp ja esimeste tähtede teke. *Pimedad ajad*, nagu neid nimetas Sir Martin Rees, on meie Universumi arengus aeg viimase hajumise epohhi, mil tekkis kosmiline reliktkiirgus, ja esimeste heledate objektide tekke vahel.

3.1 Statistics of the spatial distribution of galaxies

The main research directions in this field were the studies of the power spectrum and the correlation function of the new galaxy redshift surveys. Interesting results were obtained for the acoustic oscillations in the galaxy distributions, and for its multiscale morphology.

Gert Hütsi completed his PhD thesis "Cosmic sound: Measuring the Universe with baryonic acoustic oscillations". Many of the results described in this section were contained in this thesis.

3.1.1 Power spectrum and correlation function of the galaxy distribution


Gert Hütsi

In his thesis, G. Hütsi studied the possibility of constraining the properties of dark energy, using the information encoded in the spatial clustering pattern of the galaxy clusters selected by the Sunyayev-Zeldovich (SZ) effect. Although the spatial number density of galaxy clusters is rather low, their stronger clustering strength, as compared to the galaxies, and especially the capability of the upcoming wide-angle SZ-cluster surveys to cover large cosmological volumes, allows us to get a high fidelity measurement of the matter power spectrum on large scales. Under the assumption that redshift estimates of the clusters will be available, G. Hütsi showed that the Planck and SPT-type SZ-surveys should lead to the detection of baryonic features in the matter power spectrum. This will help to break maximum-likelihood method degeneracies between cosmological parameters, leading mainly to a tighter constraint on the dark energy equation of state parameter w_{DE}. This study was published in Astronomy & Astrophysics.

E. Saar worked on estimation of the galaxy correlation function at large distances. The inflation paradigm predicts that the pair correlation function has a single secondary maximum around 100 Mpc, and after that the correlation function smoothly approaches zero. This prediction can be checked directly by observations. So far people have searched for the maximum, have found it and have been happy with the result. Nobody has even tried to estimate the correlation function for larger distances, maybe because theory does not predict anything interesting there. So, we have a possibility to check the theory of inflation.

E. Saar started this work already in 2005, in Valencia, using the SDSS LRG (Luminous Red Galaxies) database, as this covers the largest volume in space. The results were messy, as it is difficult to process the SDSS LRG data, mainly because of very complex selection effects. In 2006 E. Saar gave the same problem to M. Sootla to study, for his bachelor's thesis. G. Hütsi helped with the most difficult job, generation of the Poisson comparison sample (the selection effects play the most important role here). This time they found a reliable result – although we see the predicted secondary maximum, we see also a number of further maxima at larger distances (Fig. 3.1). Have they proved the inflationary theory wrong?

Alas, not yet, because the selection rules for the LRG sample are extremely complex, and any systematics in the selection functions that we have not considered may give a wrong signal. There are also doubts in the main result – the existence of the secondary maximum. Figure. 3.1 shows also the correlation functions for two subsamples (the SDSS covers two separate regions in the sky). As you see, the subsample A gives a secondary maximum (this subsample is larger, and determines also the total correlation function). For the subsample B we see no peak, but a plateau, and the minima of the correlation functions differ, too.

E. Saar also checked the existence of the secondary maximum for the 2dFGRS sample (together with V. Martínez and P. de la Cruz, Valencia). In order to avoid selection corrections, they did not use the full sample, but a series of volume-limited (constant-density) samples. The result is intriguing – we see no secondary maximum, although the 2dFGRS team has found baryon oscillation harmonics for the power spectrum, meaning that the correlation function has to have a single secondary maximum. The bad possibility is that this maximum has been generated by the incompleteness corrections applied to the data. But they analysed also the correlation functions for the N-body mock catalogues, especially created to mimic the 2dFGRS, and found that its sample variance is extremely large, with a much larger rms amplitude than that of the theoretically predicted maximum itself. It means that the question is open at the moment. They continue the work, trying to get better selection corrections for the LRG and to better estimate their effect on the correlation function estimates. If these additional maxima were real, it would mean that not only adiabatic perturbations were generated at the end of the inflationary stage; maybe, isothermal perturbations had a large role, and this could seriously change our picture of the early stages of evolution of the universe.

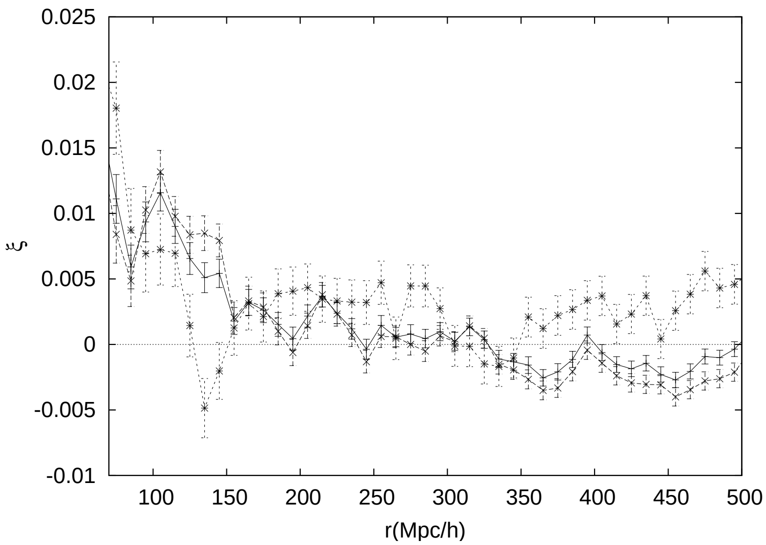


Figure 3.1: SDSS LRG correlation function for large pairwise distances. Solid line – total sample, dashed line – subsample A, dotted line – subsample B. The error limits show Poissonian 2σ errors. SDSS LRG korrelatsioonifunktsioon suurte galaktikate vahekauguste puhul. Täisjoon näitab kogu valimi korrelatsioonifunktsiooni, kriipsjoon esindab allvalimit A ja punktiirjoon – allvalimit B. Veapiirid on arvutatud Poissoni 2σ reeglist lähtudes.

3.1.2 Acoustic oscillations in the galaxy distribution

One of the new methods that have been used recently to determine the early evolution of cosmological structure is the study of acoustic oscillations in the matter distribution. Acoustic waves in the coupled baryon-photon fluid prior to the epoch of recombination will lead to characteristic maxima and minima in the matter power spectrum. Numerical simulations show that the features in the matter spectrum survive the destructive influence of nonlinear gravitational evolution, albeit in distorted form. The length scale of acoustic features can be considered a 'standard ruler' and it can be used to study the expansion history and the properties of dark energy in the Universe.

G. Hütsi analysed the two-point clustering descriptors of the galaxies in the SDSS DR4 LRG sample. This study lead to the detection of acoustic features in the redshift-space power spectrum down to the scales of $\sim 0.2\,h\,\mathrm{Mpc}^{-1}$, which corresponds to the 6th-7th peak in the cosmic microwave background (CMB) angular power spectrum. As the angular fluctuations in the CMB are strongly damped at those scales, this result shows that modern galaxy redshift surveys can provide complementary information to the precision measurements of the CMB. After correcting for nonlinearities and redshift-space distortions, using the halo model approach, the best-fit ΛCDM cosmological model was found that gives a very good match to the LRG power spectrum. This model is close to the current cosmological "concordance" model. Assuming adiabatic initial conditions and using the distance-redshift relation given by the best-fit ΛCDM cosmology, the comoving acoustic scale was measured to be $(105.4 \pm 2.3)\, h^{-1}$ Mpc. Using the WMAP data together with the value of the Hubble parameter from the HST Key Project, $H_0 = 72 \pm 8\,\mathrm{km/s/Mpc}$, the corresponding scale would be predicted to be $(107{\pm}20)\, h^{-1}$ Mpc, showing that the new result provides approximately an order of magnitude improvement over the previous prediction. This study was published in Astronomy & Astrophysics.

G. Hütsi's results show that a detailed study of acoustic oscillations in different galaxy and galaxy cluster samples is very important. The signal that we are looking for is distorted due to nonlinear effects and redshift space distortions. We must also take into account the differences between the dark matter and galaxy distributions. G. Hütsi and M. Gramann, in collaboration with O. Lahav from University College London (United Kingdom), started a detailed study of the evolution of acoustic oscillations, using numerical simulations. Starting from the present distribution of matter, it is possible to track the dynamical evolution of the large-scale density back in time and to recover the initial linear acoustic oscillations. Different reconstruction methods can be used for that purpose. Using this approach, it is also possible to analyse and model redshift space distortions. G. Hütsi, M. Gramann and O. Lahav are continuing this study, expecting to find the best methods for recovering the initial acoustic oscillations from galaxy redshift catalogues.

3.1.3 Constraints on cosmological parameters

In his third paper, published in Astronomy & Astrophysics, G. Hütsi carried out a maximum-likelihood cosmological parameter estimation by the MCMC (Markov Chain Monte Carlo) technique, using the CMB data from the WMAP experiment together with his new estimate of the comoving acoustic scale, as well as the full SDSS LRG power spectrum. This analysis focused on adiabatic, spatially flat models with negligible massive neutrino and tensor perturbation contributions. The simplest 6-parameter cosmological model was extended with the dark energy effective equation of state parameter w_{DE}. The most remarkable result is the constraint obtained for the Hubble parameter $H_0 = 70.8^{+2.1}_{-2.0}\,\mathrm{km/s/Mpc}$. This precise estimate helped to break several parameter degeneracies and allowed to determine the density parameters Ω_{cdm}, Ω_{b}, and also the dark energy equation of state parameter w_{DE} with significantly higher accuracy than those obtained for the WMAP and HST data alone. Determination of these parameters directly constrains the low redshift expansion law of the Universe. Particularly, it was found that a decelerating Universe is ruled out at the Gaussian 5.5σ confidence level.

3.1.4 Morphology of the galaxy distribution

E. Saar, together with V. Martínez (Valencia), J.-L. Starck (Paris) and D. Donoho (Stanford) continued to work on morphology of the cosmological density fields. They formulated the results of their last year's multiscale morphological analysis of the 2dFGRS as a paper which was accepted by Monthly Notices of the Royal Astronomical Society. As one of the main results of the work was that the volume of the 2dFGRS was too small to make definite predictions about the Gaussianity of the initial densities, they started to study morphology of the SDSS LRG. As noted above, using this sample needs hard work, but the analysis is done by now. Finally, they also found Gaussian morphology for the density field, but for very large scales (about 40 Mpc).

Enn Saar

They compared this result with previous studies of the morphology of the SDSS, where Gaussianity is found, as usual, for much smaller scales (about 10 Mpc). They followed the standard recipe where the point process is smoothed by a Gaussian of a width equal to the correlation radius, and obtained the same results as obtained before by other authors. They also calculated the correlation function of the new, smoothed density and found that its amplitude is small, less than 0.5 at the maximum. This means that this field is close to Poissonian. Then, they calculated Minkowski functionals for a Poissonian density field and found that these are Gaussian. Thus, strong Gaussian smoothing transforms the density field into Poissonian, and the morphology of such a field has to be Gaussian, just because of the recipe chosen. The studies made using this recipe have only checked this result, which is interesting for mathematics, but trivial for physics, and have not told us anything about the real nature of cosmological density fields. The wavelet decomposition E. Saar and his colleagues use finds much stronger deviations from Gaussianity, being a sensitive tool, but even here, the LRG sample is already too sparse. They continue the analysis, using the full SDSS sample (main plus LRG), and checking the morphological equivalence of Gaussian and Poissonian fields.

Another research direction, connected with the description of the large-scale galaxy distribution, was tuning of the filament finding algorithm, proposed by R. Stoica (Avignon), together with V. Martínez (Valencia) and E. Saar. They wrote a paper based on their last year's results on 3-D filaments for the 2dFGRS and submitted it to Journal of the Royal Statistical Society: Series C (Applied Statistics). Meanwhile, they continued searching for descriptive statistics for the filaments, and found interesting similarities with earthworm wormhole statistics. They plan to extend their algorithm to be able to find the best filament models (the set of the rules for joining filament elements). Presently the algorithm finds the best filaments for a given model.

3.2 Properties of galaxy systems

The cosmology group, together with colleagues from other observatories, continued the study of properties of galaxy systems of different scale, starting from the largest (superclusters of galaxies), until the smallest (galaxy groups).

3.2.1 Superclusters of galaxies

The cosmology group (J. Einasto, M. Einasto, E. Tago, E. Saar, L. J. Liivamägi, M. Jõeveer, G. Hütsi, I. Suhhonenko), together with J. Jaaniste (Estonian University of Life Sciences), P. Heinämäki and P. Nurmi (Tuorla), V. Müller (Potsdam), and D. Tucker (Fermilab, Chicago)) continued the study of superclusters in the 2dF Galaxy Redshift Survey (2dFGRS) and the Sloan Digital Sky Survey Data Release 4 (SDSS DR4). Supercluster catalogues were published in Astronomy & Astrophysics and were made available on the group web site. They also compiled catalogues of simulated superclusters, using the Millenium Simulation results (these are the largest numerical simulations available which also contain simulated galaxies).

They compared the properties of the observed and simulated superclusters. The most important difference between the observed and simulated superclusters is their multiplicity – about ten times more massive (luminous) superclusters are found in observations than in simulations (Fig. 3.2). The reason of this difference is not yet clear; several studies are in progress to clarify that.

The supercluster catalogues contain superclusters of very different richness from very poor superclusters, similar to the Local Supercluster, up to extremely rich superclusters, which contain tens of rich clusters of galaxies, including X-ray clusters. The cosmology group compared the geometrical and physical properties of superclusters of different richness: their sizes, shapes,

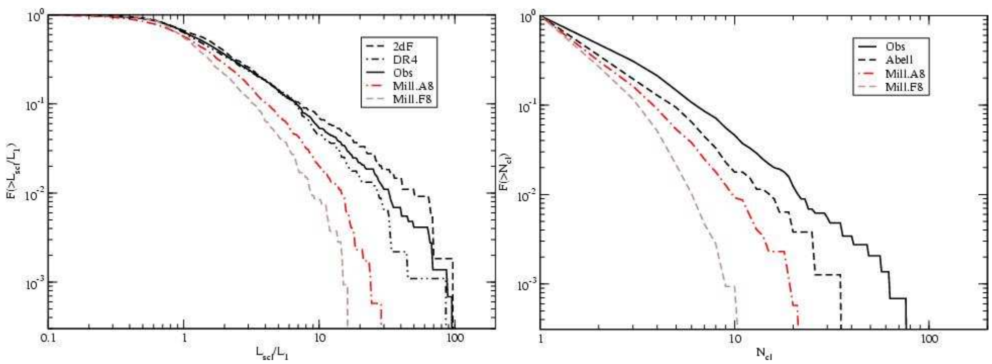


Figure 3.2: Comparison of luminosity functions (left panel) and multiplicity functions (right panel) of observed and model (Millennium) superclusters. Vaadeldud ja mudel-superparvede heledusfunktsioonide (vasakpoolne joonis) ja kordsusfunktsioonide (parempoolne joonis) võrdlus.

compactness and symmetry, mean densities and other properties. This study showed that rich superclusters are not only of larger sizes than poor superclusters, they also have larger mean densities of galaxies. This fact shows that superclusters are physical systems with properties depending mainly on supercluster richness, and not just artificial assemblies of galaxy clusters, groups and single galaxies. Rich superclusters are also less symmetrical than poor superclusters, and less compact (more filamentary) than poor superclusters.

Moreover, rich superclusters contain high density cores with relative densities $\delta > 10$, while in poor superclusters such high density cores are absent.

The group also studied the properties of galaxies in rich and poor superclusters and, for comparison, in the field. One may expect that the properties of galaxies in different superclusters are, in average, the same. However, this study showed several unexpected results. They demonstrated that the fraction of early type, passive galaxies in rich superclusters is slightly larger than in poor superclusters, and is the smallest among the field galaxies. Most importantly, in high density cores of rich superclusters ($\delta > 10$) there is an excess of early type, passive galaxies in groups and clusters, as well as among isolated galaxies. In other words, in high density cores there are less star-forming galaxies than in less dense environments in superclusters. In addition, the main galaxies of rich superclusters have larger luminosities than those of poor superclusters and of groups in the field. It has been shown before by other authors that galaxy morphologies depend on the local (group/cluster) environment up to distances of 1–2 cluster virial radii. The results of the Tartu cosmology group show that both the local (group/cluster) environment and the global (supercluster) environment influence galaxy morphologies and their star formation activity.

M. Einasto and E. Saar began to study the morphology (shapes, sizes and substructures) of the richest superclusters, both in observations and in the Millenium Simulation. Two richest observed superclusters are shown in Fig. 3.3. In particular, they use Minkowski functionals and shapefinders to describe the properties of superclusters. Several other members of the cosmology group (L. J. Liivamägi, J. Einasto) and V. Martínez (Valencia) and J.-L. Starck (Paris) have joined this study. An interesting preliminary result is that the observed superclusters have a characteristic shapefinder signature that can be modelled by a simple multibranched filamentary structure.

From left Vasakult paremale: Erik Tago, Jaan Einasto, Maret Einasto, Lauri Juhan Liivamägi

3.2.2 Clusters and groups of galaxies

E. Tago continued the compilation of the database of rich clusters in collaboration with H. Andernach (Mexico). The catalogue contains redshifts for 4706 clusters and velocity dispersions for 2642 clusters. It has been and will be used to study the spatial distribution of the clusters and to determine the cosmological matter density parameter.

E. Tago compiled catalogues of groups based on the Sloan Digital Sky Survey Data Releases 4 and 5, which include 565 715 and 674 749 galaxy redshifts, respectively. For final analysis he used only the data of the latest data release, DR5. To generate the group catalogue he applied a modified FoF (Friends-of-Friends) method that takes into account the density-luminosity relation in observed groups, yielding a FoF linking length that only slightly increases with redshift. The scaling law for the linking length was determined by shifting of the nearby observed groups to larger distances and determining their observed properties.

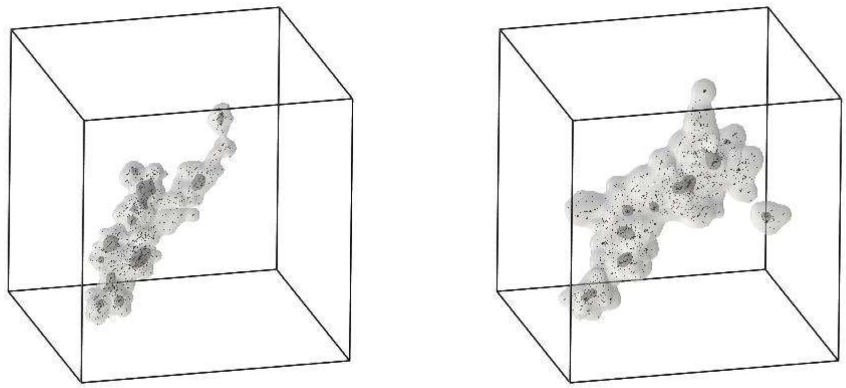


Figure 3.3: Two richest 2dFGRS superclusters. Left panel – supercluster 9 (cube size 122.4 Mpc/h), right panel – supercluster 126 (cube size 93.6 Mpc/h). Kaks rikkaimat 2dFGRS superparve. Vasak paneel – superparv 9 (kuubis suurusega 122.4 Mpc/h), parem paneel – superparv 126 (kuubis suurusega 93.6 Mpc/h).

The final SDSS group catalogue consists of 53 048 groups. It was used to study the group luminosity function, the global luminosity density field, the group properties in various large scale environments and for compilation of a supercluster catalogue.

J. Vennik studied galaxy interactions in small dense groups of galaxies. He found the interaction probabilities for a galaxy group, dominated by the galaxy IC 65, using a perturbation parameter, which describes moderately disturbed extended gaseous haloes as well as marginally disturbed stellar disks in several group galaxies. These predictions have been found to be generally confirmed by the recent surface photometry by J. Vennik. As an another characteristic, which could probably manifest the interactions – the star-formation activity (SFA) in giant and dwarf group members – was analysed. It was found that the luminous galaxies show either nearly continuous or slowly decreasing SFA, but short star-bursts (e.g., induced by minor mergers) cannot be excluded. The dwarf satellite of the parent galaxy of the group is nesting a chain of star-forming knots of different age. Other, relatively isolated possible dwarf group members do not show excessive SFA.

In order to model galaxy clusters and groups, P. Heinämäki, P. Nurmi and J. Holopainen (Tuorla), together with E. Saar, M. Einasto and J. Einasto and V. Martínez (Valencia), built ΛCDM cosmological simulations with different resolution and volumes. Using N-body simulations with a broad scale of mass and spatial resolution, they studied the structure of dark matter haloes and

From left Vasakult paremale: Jaan Vennik, Urmas Haud, Margus Sisask

the distribution of masses and the spatial distribution of subhaloes within the main haloes. Dark matter haloes were identified using an algorithm that is based on the adaptive grid structure of the MLAPM simulation code. The haloes encompass the mass scale from $10^8\,M_\odot$ to $10^{15}\,M_\odot$. They determined the subhalo mass function for such haloes, where it was possible to resolve substructure, showed that the subhalo mass function can be described by the Weibull distribution, and that it depends slightly on the redshift.

L.J. Liivamägi and E. Saar continued developing a wavelet-based algorithm for extracting galaxy groups from galaxy redshift catalogues. They extended their previous 2-D approach to 3-D, analysed the rules for defining groups of different scales, and studied the possibility of applying steerable wavelets for this task. This work is in progress.

3.3 Single galaxies

Galaxies form the basis of all large-scale cosmological structure studies, and their properties and evolution carry important clues on the history of the universe. The galaxy physics group studied both distant and nearby galaxies, developed their dynamical models and applied these to observations. Distribution of the neutral hydrogen in our Galaxy was studied as well.

This year Antti Tamm defended his PhD thesis ”Structure of Distant Disk Galaxies”.

3.3.1 Structure of distant disk galaxies

Comparison of local galaxies with those at large distances (and observed at earlier times) allows to directly study galactic evolution. A photometric survey of distant disk galaxies on the basis of high-resolution Hubble Space Telescope near-infrared imaging was carried out by P. Tenjes and A. Tamm. In total, 22 galaxies in the redshift range $0.5 < z < 2.6$ were analysed, reaching a look-back time of 10 Gigayears.

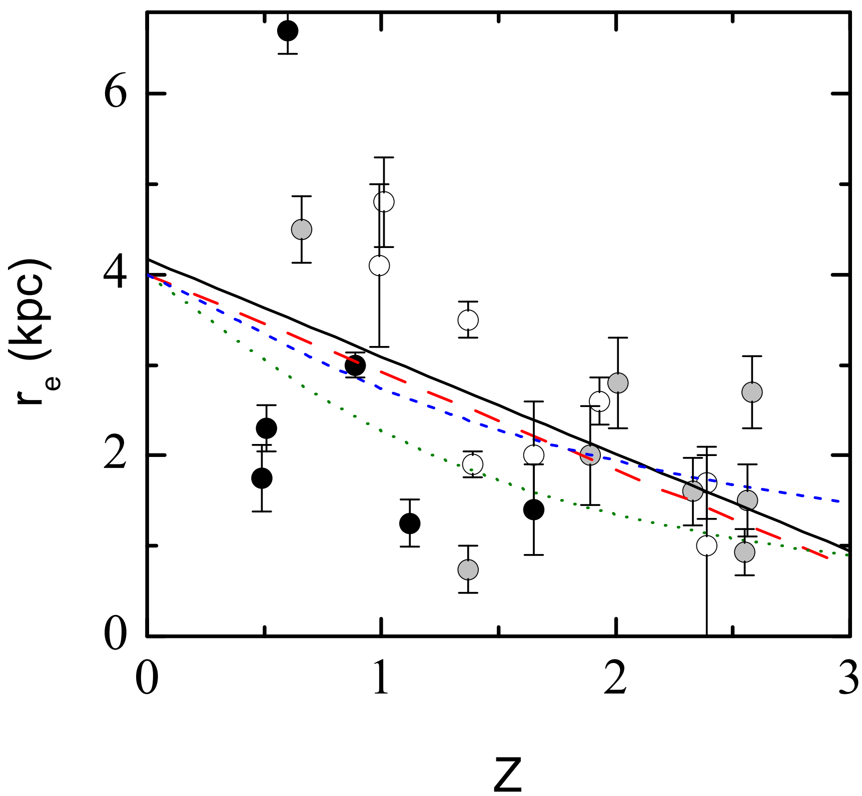


Figure 3.4: Disk sizes as a function of redshift for the Hubble Deep Field South NICMOS field. The size of the data points represents different luminosities of galaxies. The solid line is a linear fit to the data, other lines are theoretical predictions. Ketasgalaktikate mõõtmed Hubble Deep Field-South NICMOS-kaamera vaateväljas punanihke funktsioonina. Sümbolite erinevad suurused iseloomustavad galaktikate heledust. Must pidevjoon näitab lineaarset seost $r(e)/r(0) = 1 + 0.26z$, teised jooned – teoreetilisi mudeleid.

Single-component Sérsic model distributions were fitted to the rest-frame B-luminosity profiles. The half-light radii showed a systematic decrease towards higher redshifts within all three bins of absolute luminosity (Fig. 3.4). Reproduction of the observed size evolution of disks with redshift is a good test for galaxy formation theories. The relation found for the HDF-S NICMOS field galaxies $r(e)/r(0) = 1 + 0.26z$ is in good concordance with computer simulations and theoretical predictions arising from hierarchical clustering scenarios.

The rest-frame *(U–V)* colours and colour distributions at different redshifts were compared. Galaxies at high redshifts were found to be bluer, with inner regions bluer than outer regions. Blue colours are probably an indication of active star formation, so early galaxies form stars very intensely and the star forming regions are centrally concentrated. The results were published in a paper in Astronomy & Astrophysics and were reported by A. Tamm at the conference "Cosmic Frontiers" in Durham, UK.

These and the previous studies of the structure of distant disk galaxies formed the basis for the PhD thesis of A. Tamm, "Structure of Distant Disk Galaxies", supervised by P. Tenjes. In the dissertation, first an overview of the current knowledge of galaxy evolution, acquired from observations and computer simulations, was given. Thereafter, the methodology and the results of the study of self-consistent mass-distribution models of disk galaxies at high redshifts (up to $z = 1$) and of the photometric study of galaxies at even higher redshifts, were described. A conclusion was reached that from the redshift $z = 1$ until now (over the last 6 Gigayears), no significant evolution of stellar mass-to-light ratios and central densities of dark matter haloes has taken place. For more distant galaxies, considerable changes in disk sizes and star formation rates were found.

3.3.2 Structure of local disk galaxies

Detailed studies of the structure of disk galaxies have been conducted at Tartu for more than half a century. P. Tenjes and E. Tempel (a PhD student of Tartu University) continued developing detailed hydrodynamic models of nearby galaxies, assuming the general case of a three-axial velocity ellipsoid. The initial model did not enable to solve Jeans equations as a system, this problem has now been solved.

The model was applied to the well observed edge-on Sa galaxy M 104. As the initial data, a previously developed photometric model was used, with the addition of the luminosity profile for the central region of the galaxy from the HST archive data and of the measurements in red and infrared filters. The modelled kinematics allowed a satisfactory match to the measured velocity dispersions in three planes parallel to the major axis of the galaxy and for two planes parallel to the minor axis. As a result, a self-consistent hydrodynamical model for M 104 was derived and published in Monthly Notices of the Royal Astronomical Society, together with a description of the algorithm. In the best-fitting model, the velocity dispersion ellipsoids are radially elongated. Velocity dispersions outside the galactic plane are sensitive to the dark matter distribution, thus the model enables to discriminate between the contributions to the total mass distribution by the disk and by the dark matter halo. As a new feature, the algorithm now also allows to use different dark matter distributions (NFW, isothermal, etc).

E. Tempel, together with E. Saar, continued developing detailed phase space models of our Galaxy, using the Schrödinger-Poisson method. It is hoped that this method might give a much better description of the velocity distribution than the usual N-body simulations. The initial version of the code is almost completed, but there are no results so far. The problem is in calculating the phase density, based on a given wavefunction; it is not clear yet how to determine the necessary number of wave packets and how to rescale the real space quantities into their quantum counterparts.

3.3.3 Dark matter in galaxies

Using the improved hydrodynamic model and models for the chemical evolution of stellar components, A. Tamm, E. Tempel and P. Tenjes started a study of the spatial density distribution of dark matter in central regions of galaxies.

From left Vasakult paremale: Peeter Tenjes, Elmo Tempel, Antti Tamm

The most accurate photometric, spectroscopic and kinematic data are available for the Sb galaxy M 31, which was chosen to be studied first. For M 31 the stellar dispersions and rotation velocities are available for the whole meridional plane within the central region of the galaxy; observations of planetary nebulae for the outer parts of galaxy can also be used. On the basis of the surface brightness distributions in different colours, the colour indices

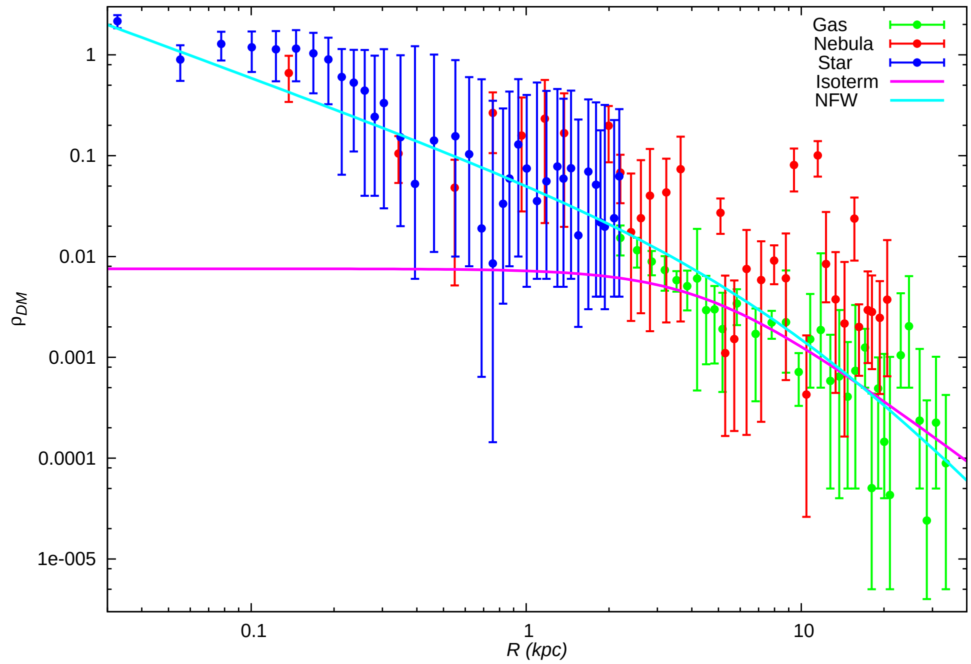


Figure 3.5: Dark matter distribution in Andromeda galaxy. The observed velocity dispersions and rotational velocities are used to model the stellar component and observations of planetary nebulae and rotational velocities are used to model the gas distribution. Solid lines show the best-fitting NFW and isothermal profiles for the dark matter distribution. Ainetiheduse jaotused Andromeda galaktikas kiiruste dispersioonide ja pöörlemiskiiruste põhjal tähelise komponendi ja planetaarudude jaoks ning ainult pöörlemiskiirustest leitud jaotus gaasi puhul. Pidevate joontega on toodud NFW ja isotermiline tumeaine jaotus.

(*B*–*V*), (*B*–*I*), (*B*–*K*) etc. of the galactic components (bulge, thick disk, thin disk, stellar halo) were estimated. Together with the available measurements for the metallicity of the stellar matter in M 31, the colour indices were used for estimating the ages and mass-to-light ratios of the stellar components. For this purpose, chemical evolution models of simple stellar populations by different research groups were used. These models describe the evolution of a single-burst stellar population with a given initial mass function in time and allow to calculate the corresponding integral colours and masses.

Using the estimates for the masses and mass-to-light ratios and the hydrodynamic modelling code developed by E. Tempel, the rotation velocities and velocity dispersions, generated by the gravitational potential of the stellar components, were calculated. Assuming the difference between the calculated and the actual kinematics of the galaxy to be caused by the gravitational potential of a dark matter halo, the density distribution of the halo was found. The results are somewhat surprising: instead of an isothermal distribution as usually found, an NFW-profile, similar to the results of N-body simulations, was suggested by the analysis (Fig. 3.5). This demonstrates that there might be no conflict between N-body simulations and actual galaxies; if we do not account properly for velocity dispersions, we systematically underestimate the true gravitational potential in the central regions of galaxies. In addition to M 31, the dark matter distribution in the galaxy M 104 has also been studied by now; the initial results confirm the results found for M 31.

3.3.4 Structure of H I in the Galaxy

The distribution of H I in the Galaxy was studied by U. Haud. He wrote four papers on the subject, based on the results of the studies of last years (Gaussian decomposition of H I profiles and their physical interpretation). These papers have been submitted to different journals (Astronomy & Astrophysics, Baltic Astronomy).

U. Haud also participated in the project that attempts to constrain the dark matter models of our Galaxy on the base of the shape of an unperturbed gaseous disk. These studies were undertaken by the astronomers of the Argelander-Institut für Astronomie of Bonn University. In these studies, the Leiden/Argentina/Bonn all sky 21-cm line survey was used, and the 3-D H I volume density distribution for the Milky Way was derived, up to galactocentric radii of 60 kpc and to heights of 20 kpc. Besides a massive extended halo of $M \sim 1.8 \cdot 10^{12}\,M_{\odot}$, a self-gravitating dark matter disk of $M \sim 1.5 \cdot 10^{11}\,M_{\odot}$, including a ring at $R \sim 15\,\mathrm{kpc}$ with $M \sim 2.4 \cdot 10^{10}\,M_{\odot}$ was found. This ring had been previously postulated on the basis of the EGRET data and it coincides with a giant stellar structure that surrounds the Galaxy. The resulting Milky Way rotation curve is flat up to $R \sim 22\,\mathrm{kpc}$ and slowly decreases outwards. The H I gas layer is strongly flaring. The HWHM scale height is 60 pc at $R = 4\,\mathrm{kpc}$ and increases to $\geq 3000\,\mathrm{pc}$ at $R \geq 45\,\mathrm{kpc}$. The Milky Way has a well defined exponential H I disk with a radial scale length of 3.75 kpc in surface density that extends at least to $R \sim 30\,\mathrm{kpc}$. At larger distances the HI distribution is shallower, with surface density decreasing slowly outwards. The Galactic warp is well described as a homogeneous feature in three Fourier modes with slowly variable phases up to $R \leq 45\,\mathrm{kpc}$. The nodal line of the gas at larger distances is trailing.

3.3.5 Empirical models of galaxies

E. Tempel, E. Saar and M. Gramann started modelling the formation of galaxies in dark matter haloes. They use a Monte-Carlo technique, where the merging histories of haloes are generated randomly, using certain empirical rules. This technique is simpler and faster than detailed tracking of the merging histories of N-body haloes. We might lose possible correlation between the merging histories of neighbouring haloes, but, as N-body simulations start from random realizations of the initial conditions, the merging histories are stochastic, anyway. This method gives a model galaxy for every halo in a single event, and, finally, leads to probability distributions of galaxy properties, depending on their host halo parameters. If we now find a halo sample from a N-body simulation, we can generate galaxy samples that correspond to these haloes.

E. Tempel wrote a program that allows to follow the merging of haloes, cooling of the halo gas, star formation in galaxy disks, and the evolution of the chemical abundances in the gas. After adding the stellar evolution history (evolutionary tracks), he can predict the luminosities of model galaxies.


Mirt Gramann

For studies of large-scale structure, the most important variables of galaxy samples are the positions and velocities of galaxies and their luminosities. The positions and velocities can be obtained from conventional N-body models, finding their dark matter haloes and subhaloes. In order to get galaxy luminosities, we have to model galaxy formation in haloes. This has been done before, using both the Monte-Carlo technique and direct tracing of halo merging histories in N-body simulations, and adding galaxy evolution code.

The largest simulation of both the dark matter and galaxy evolution is the Millennium Simulation. Its results can be ”observed” in the German Virtual Observatory database. The database itself includes data on more than billion galaxies, with their morphological type, stellar mass, luminosity in different filters, etc., together with the properties of their host haloes.

As this database is so large, it can be used as the parent population. Given a N-body halo (or subhalo), we can randomly select a galaxy from a subset of this database, restricted by the dark halo properties. This approach is equivalent to the Monte-Carlo method described above, but we omit building model galaxies and use galaxies produced by others.

In order to select a specific galaxy, a kernel method is used; we select, first, a kernel of proper widths, both in the halo redshift and its mass, and select a Millennium galaxy, using the kernel weights. E. Tempel has written a program that queries the database, gives a list of dark matter haloes, and produces a model galaxy sample.

E. Tempel tested this method on a sample of dark matter haloes along a lightcone. The method works, although in order to fully populate a lightcone, the halo list should include subhaloes; at the moment it does not yet, and part of the galaxies is missing. After the lightcone code (E. Saar's addition to A. Knebe's MLAPM code) starts producing subhaloes, the galaxy content of deep observational samples can be predicted.

In order to check if the only halo properties determining their galaxy content are the halo redshift and its mass, E. Tempel searched for the dependence of galaxy properties on the halo environment (its environmental density). The preliminary conclusion is that there is no correlation, but the extra parameter problem has to be explored more carefully, looking for correlations between the halo properties and different properties of model galaxies (e.g., their morphology). Model galaxy catalogues will be built, given N-body haloes and subhaloes, together with P. Heinämäki and P. Nurmi (Tuorla).

3.4 Dark ages and the first stars in the universe

The "dark ages", as it was called by Sir Martin Rees, is an epoch in the history of our universe between the time of the last scattering, where the primary cosmic microwave background formed, and the birth of the first luminous objects. This is the research subject of E. Vasiliev, our postdoc from Rostov University (Russia).

As the universe is predominantly neutral during the dark ages, its contents can be observed in the redshifted 21 cm line of the atomic hydrogen. There are a few mechanisms and processes that lead to excitation of the 21 cm transition. E. Vasiliev and Y. Shchekinov (Rostov) found that decaying dark matter can influence the 21 cm line emission. Extra ionizing photons and heating from the decay of the dark matter particles strongly change the characteristics of the 21 cm emission. Emission signatures depending on the type of the dark matter particles within in the detection limits of the planned giant meter-wavelength telescopes as LOFAR, LWA, SKA, and future observations of the epoch of the dark ages could put constrains on the physics of decaying dark matter.

Another direction of E. Vasiliev's research is connected with the properties of the first and second stellar generations. The first stars are formed from metal-free gas; the usual assumption is that there exist only a few efficient coolants at the low gas temperatures. Because of that, the first stars are believed to be massive, about hundreds of solar masses. But in some physical conditions the HD (hydrogen+deuterium) molecules are favoured to form in sufficient amounts. Those molecules are very efficient coolants at very low temperatures, and gas can be easily fragmented into smaller clouds, which may give birth to less massive stars, with masses close to those of normal stars in our Galaxy. E. Vasiliev and Y. Shchekinov pointed out that such (favourable for HD formation) conditions are realized in mergers of massive haloes at high redshifts. Thus, the birth of low-mass stars could be possible in the primordial gas as well.

The first stars explode as very energetic supernovae and enrich the environment with metals, which induce more rapid cooling and the formation of the second population of stars. The transition from the less efficient molecular cooling to a more efficient metal cooling is thought to happen at a certain value of metallicity – the critical metallicity. E. Vasiliev and Y. Shchekinov demonstrated that the value of critical metallicity depends strongly on the abundances of the H_2/HD molecules and on the previous history of the gas. For high molecular fractions, the dependence of the critical metallicity on gas density is very steep, and the critical metallicity can be lower than 10^{-5}. Thus, the extremely low-metallicity stars, observed in our Galaxy, can be the relics of the transition from the first to the second stellar generations.

4 Structure, chemical composition and evolution of stars Tähtede ehitus, keemiline koostis ja evolutsioon

Tähed on Universumi struktuuri olulised komponendid, milles toimuvad füüsikalised protsessid kujundavad galaktikate ja sedakaudu kogu Universumi evolutsiooni. Teiselt poolt on ainult tänu tähtedele võimalik planeetide, sealhulgas ka Maa-taoliste olemasolu. Üheks võtmeprobleemiks selliste seoste mõistmisel on tähtede keemiline koostis ja selle evolutsioonilised muutused.

2006. aastal uuriti tähefüüsika teema raames enamasti juba traditsiooniliseks kujunenud objekte ja nähtusi. Jahedate hilisesse evolutsioonistaadiumisse jõudnud tähtede uuringud keskendusid peamiselt objektile CGCS 6857, mis kuulub süsinikurikaste protoplanetaarsete udude väikesearvulisse rühma. Tema keemiline koostis ja ümbrise omadused viitavad seostele tähe metallisisalduse ja mitmete füüsikaliste protsesside iseärasuste vahel. Jahedate tähtede hulka võib liigitada ka juba mitu aastat uurimise all olnud iseäraliku tähe V838 Mon, kuigi viimane aasta andis meile järjest rohkem tõendeid, et tegemist võib olla kaksiktähega, kus teine komponent on kuum B-spektriklassi täht.

Tähtede temperatuurijada kõige kuumemas otsas asuvate O- ja B-spektriklassi ning Wolf-Rayet (WR) tähtede puhul oli muude hulgas üks olulisemaid tulemusi arusaam, et intensiivset tähetuult genereeriv aine väljavool saab alguse väga sügaval tähe sisemuses, tänu tähe konvektiivse südamiku aeglasel kokkutõmbumisel vabanevale gravitatsioonienergiale. Nii kuumade tähtede kui muude meie vaatlusprogrammi objektide vaatlused muutusid efektiivsemaks (parem signaal-müra suhe, lühemad ekspositsiooniajad) tänu märtsis 2006 tööle rakendatud uuele CCD kaamerale.

Jätkus töö tarkvarapaketiga SMART, mis on meil loodud kuumade tähtede mudelatmosfääride arvutamiseks ning neis toimuvate füüsikaliste protsesside ja väljakiiratava tähespektri uurimiseks. Peatähelepanu pöörati arvuti mälumahu kokkuhoiule suurte andmemassiivide teisendamise teel ning Starki efekti arvestamisele vesiniku ja heeliumi spektrijoonte arvutamisel. Töötati välja uus meetod täheatmosfääride keemilise koostise ja selle vertikaaljaotuse määramiseks kaalutud vaatlusandmete ja kaalutud mudelspektrite parima ühildamise teel – selleks on vaja kõrgekvaliteedilisi vaatlusandmeid (spektraalne lahutus 100 000 ringis, signaal-müra suhe vähemalt 200).

Kaksiktähtedest olid uurimise all peamiselt HR-diagrammi nn horisontaalse haru ehk EHB tähti sisaldavad süsteemid ja sümbiootilised tähed. Õnnestus leida lihtne analüütiline seos EHB kaksiktähtede massi väljavoolu kiiruse ning süsteemi kogumassi jm parameetrite vahel. Täpsustati kaksiktähe RX Cas mudelit. Vaatluslikust aspektist oli huvitavaks tulemuseks selliste märkide esmakordne leidmine hästiuuritud sümbiootilise tähe Z And spektrist, mis viitavad tähe kuumast komponendist väljuvatele kiiretele (ca 1700 km s^{-1}) kitsalt suunatud gaasijugadele.

Euroopa Kosmoseagentuuri satelliidi Gaia (start planeeritud detsembris 2011), mille andmetöötluse ettevalmistuses on meie tähefüüsikud mitu aastat osalenud, fotomeetriliste mõõtmiste kontseptsiooni muudeti hiljuti. Seetõttu on oluliselt suurenenud emissioonijoontega tähtede osatähtsus Gaia fotomeetrilise süsteemi kalibreerimisel ning meie kogemused ja tulemused on tubliks toeks Gaia vastavale töörühmale.

Uued statistilised meetodid astronoomiliste aegridade töötluses andsid muuhulgas tulemuseks, et Päikesel siiski ei ole "nägu" – teiste sõnadega, ilmselt ei toimu päikese aktiivsuse tsentrite sellist triivi ja nn *flip-flop* tüüpi ümberlülitumist ca 3.7 aasta tagant nagu mõned teised uurijad on leidnud. Täiustati gravitatsiooniläätse efektist tingitud kaksikkujutiste lahutamise metoodikat.

Kiirgusvälja käitumise uurimisel sügaval atmosfääri sees kasutati nõrgenemiskoefitsiendi numbrilist arvutamist erinevate mõõtmetega hajutavate ja neelavate osakeste puhul. Universumi võimsaimate teadaolevate plahvatuste – gammakiirguse sähvatuste – uurimisel on abiks meie tööd kiirguslike protsesside (sünkrotronkiirgus ja -neeldumine, Comptoni hajumine) kirjeldamisel relativistlikus plasmas. Seejuures käsitleti võimalikult laia osakeste ja footonite energia vahemikku.

4.1 Late-type stars

The studies of post-AGB stars and stars after the final helium-shell flash were continued by T. Kipper and V.G. Klochkova (Special Astrophysical Observatory, Russia).

In 2006, the post-AGB star CGCS 6857=IRAS 20000+3239 was studied. This star has a considerable IR-excess caused by large amount of circumstellar material. It belongs to the small group of C-rich protoplanetary nebulae (PPN) displaying in their IRAS LSR spectra a still unidentified emission feature around 21 μm. We observed the star with the prime focus echelle spectrometer PFES of the 6-meter telescope of SAO RAS.

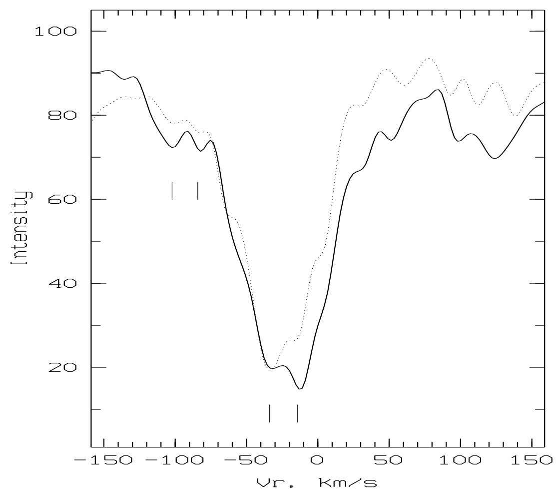


Figure 4.1: The profiles of the Na I D lines in the spectrum of CGCS 6857 in velocity scale. Four components of the lines are indicated. Na I D jooned CGCS 6857 spektris kiiruste skaalas. On märgitud neli komponenti.

T. Kipper and V. Klochkova measured radial velocities of various groups of atomic lines and molecular bands. They found that the Na I D doublet consists of four components, three of which may be interstellar or due to distant expanding envelopes.

They also analysed the chemical composition of the star's atmosphere. The obtained abundances show that CGCS 6857 is really a post-AGB star: it is overabundant in carbon and nitrogen and shows especially large excess of heavy s-process nuclei. It is known that not all post-AGB candidates show such details of chemical composition, only a small group (six stars) of PPN, which display an emission band at 21 μm, are C-rich and have large overabundances of s-process elements. The latter feature is a direct evidence of third dredge up (TDU) in these stars. The low metallicity of CGCS 6857 supports the earlier conclusion that TDU is more efficient in metal-poor stars.

I. Kolka in collaboration with T. Kipper and T. Liimets has investigated the available archival spectra and photometric time-series obtained at Tartu Ob-

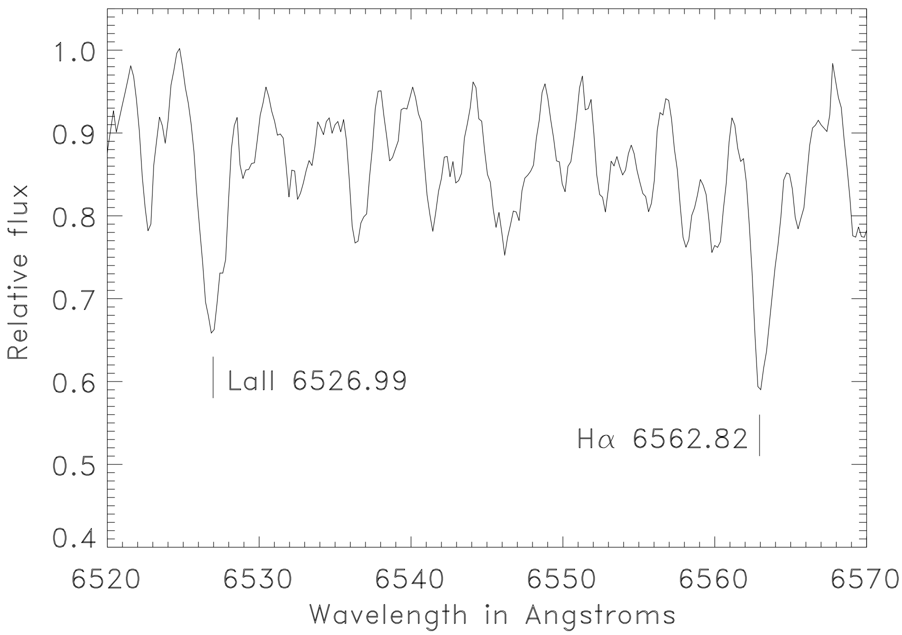


Figure 4.2: The portion of the spectrum of CGCS 6857 bracketed by the La II and the Hα lines. Both lines are heavily blended by CN lines. The almost equal intensity of La II and Hα lines is result of the overabundance of elements produced in s-process. Osa CGCS 6857 spektrist La II ja Hα joonte vahel. Mõlemad jooned on tugevasti blendeeritud CN pöörlemisjoontega. La II ja Hα joonte peaaegu ühesugune intensiivsus on s-protsessis toodetud elementide suurenenud sisalduse tulemus.

servatory for the peculiar variable star V838 Mon. The comparison of brightness data on V838 Mon and its light echo with contemporaneous published results points to the reasonable quality of our measurements to be included in the international database on this object. The archival spectra of V838 Mon demonstrated strong evidences of the interaction between the gas expelled from V838 Mon and a hotter secondary component indicating that this variable is a physical binary star. The results on V838 Mon were presented in May 2006 on La Palma, Spain at the conference dedicated to this object.

4.2 Hot luminous stars

After a few years delay the investigation of the yellow hypergiant HR 8752 has been continued. The spectra recorded at Tartu Observatory in 2000–2005 (19 nights in total) will be analysed in collaboration with C. de Jager and

From left Vasakult paremale: Tiina Liimets, Tõnu Kipper, Indrek Kolka

H. Nieuwenhuijzen (The Netherlands) in order to find out the causes for variability of the effective temperature of this star.

The O-type star HD 191612 changes its spectral type with the period of $\sim$ 540 days. The true nature of this variability is still unclear, and the cooperative spectral monitoring of HD 191612 is a continuing effort of several observatories (the PI is I. Howarth from University College London, UK). The observations at Tartu (K. Annuk, L. Leedjärv) have been reduced by I. Kolka and added to the common database used in the analysis which is in progress at UCL. A similar star (HD 108) was also included in the spectroscopic monitoring programme at Tartu Observatory.

T. Nugis continued modelling of Wolf-Rayet (WR) star winds (in collaboration with H. Lamers, The Netherlands) and started the investigations to clarify what is the cause of matter outflow and how deep inside the star the matter flow starts in the case of hot stars (OB and WR stars). The winds of WR stars are optically thick in continuum (their sonic points are located at large optical depth in continuum) and the winds of OB stars are optically thin. Both, the optically thick and thin wind models consist of a ”circular argument” that the wind is existing.

T. Nugis found that in the case of the core-burning hot stars (WR and OB stars) the flow can start already very deep inside the star (near the convective core surface) due to the liberation of the part of the gravitational energy followed by the slow contraction of the core.

From left Vasakult Tiit Nugis, Kalju Annuk

T. Nugis, K. Annuk and A. Hirv (in collaboration with A. Niedzielski and K. Czart from Toruń, Poland) completed the reduction of the observations of mid-IR spectra of WR stars and are preparing the data for publication. The spectral observations were carried out with the 1.5-m telescope of Tartu Observatory (northern stars) and with the Radcliffe 1.9-m telescope of SAAO (South Africa, southern stars).

K. Annuk continued spectroscopic observations of WR stars using the 1.5-m telescope. He observed binary systems as well as supposed single stars. Observing programme of the binary systems is long-term and has been continued for more than twenty years. The aim of this programme is to specify the orbital parameters of these systems. Partially, this work was carried out in cooperation with S. Marchenko (Western Kentucky University, USA).

Profile variations of emission lines in the both single and binary WR stars were studied. It was found that most observed stars show remarkable profile variations. In summer 2006, K. Annuk started observations of the WR star WR 148, also in cooperation with S. Marchenko. Most likely, this star has a compact companion, neutron star or black hole.

K. Annuk also continued spectroscopic observations of the Be star Pleione (BU Tau).

4.3 Modelling of stellar atmospheres and formation of spectra in them

Recent rapid progress in the high-precision and high spectral resolution astrospectroscopy and in the computer facilities has produced the situation where large class of different stellar atmospheres and physical phenomena in them can be studied in detail and compared with the observational data.

Such studies have also been carried out at Tartu Observatory.

The Fortran-90 software SMART, composed by A. Sapar, R. Poolamäe and A. Aret for computation of model atmospheres of hot stars and for study of physical processes in their atmospheres, including radiative transfer and formation of emergent stellar spectra, has been improved. New packing and unpacking software for the obtained high-resolution synthetic spectra and high-resolution limb darkening data has been composed. It reduces the data to a form, which enables to zip them into files several times smaller than if zip procedure were applied directly. As a result, significantly more of the bulky spectral data can be stored on a DVD disk for further studies. Composed program enables to compute the detailed spectra of spherical stars with any rotation velocity and orientation of rotation axis, and also the light curves of undistorted eclipsing close binaries using the limb darkening data as input.

R. Poolamäe has composed a modified C++ code for computing stellar spectra of somewhat wider range of spectral classes than SMART. Due to more precise but complicated algorithms for computing the Stark broadened H and He line profiles, it is also well applicable to white dwarfs.

Compact analytical expressions for the Stark broadened spectral line profiles have been derived by A. Sapar, R. Poolamäe and L. Sapar. Necessary high-precision analytical formulae for the Holtsmark profile function have been found using series expansions at small and large values of the line argument, and a best fit formula at the intermediate values of the argument. This best fit expression has a form of the ratio of two polynomials. Numerical calculations showed that relative error less than 10^{-7} is obtained if 30 terms of the expansion are taken into account.

The spectral line profile function, which forms as a convolution of Stark, Doppler and Lorentz profiles, has also been studied. Double analytical integration of the expression has been carried out. Thereby the computation of the profile function has been reduced to a sum of three single integrals, describing correspondingly the contributions of Stark, Doppler and Lorentz profiles into the total profile function. The analytical formulae have also been found for these contribution functions at the small and large argument values of Holtsmark profile function using the series expansions. For the intermediate profile region, however, it is necessary to carry out numerical integrations and the suitable expressions for summation and integration have been proposed.

4.4 Diffusion of chemical elements and their isotopes in the chemically peculiar (CP) stellar atmospheres

Improvements of the theory of diffusion of chemical elements and their isotopes in the stellar atmospheres due to radiative pressure and light-induced

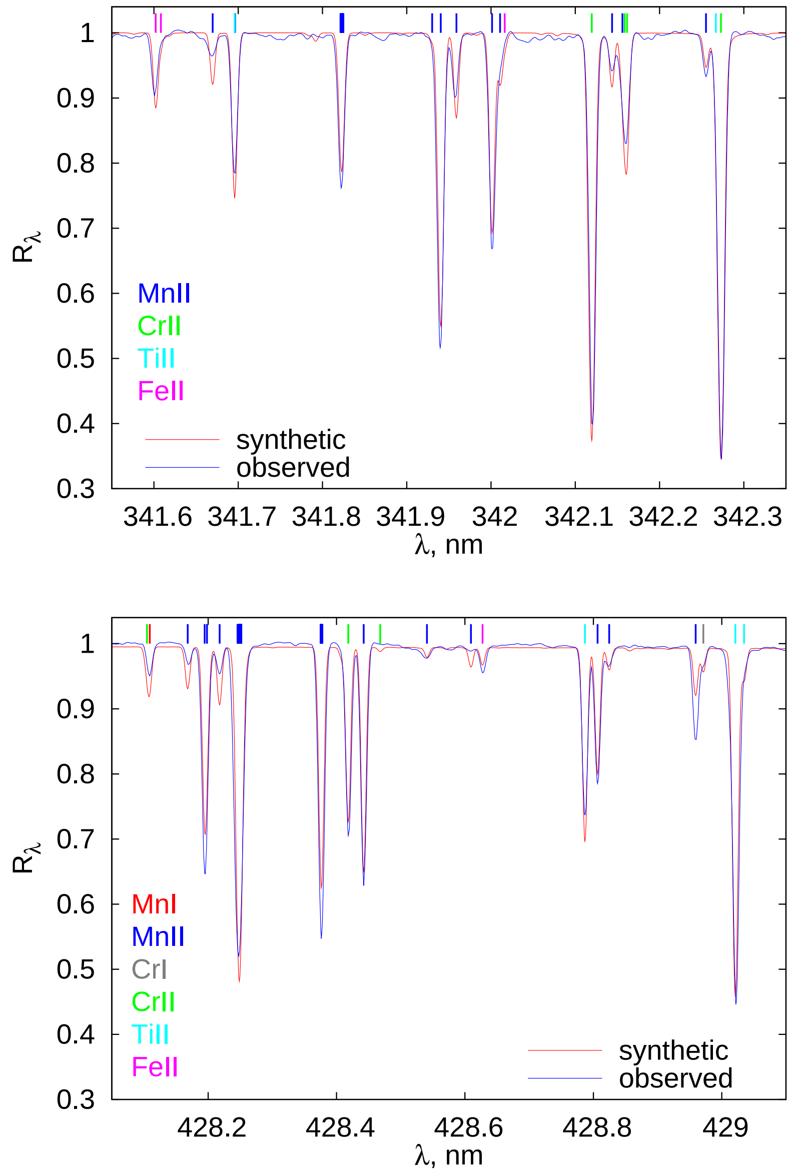


Figure 4.3: Comparison of observed and synthetic spectra of the CP star HR 175640 in the ultraviolet (upper panel) and visual (lower panel) regions. The observed spectra have been obtained with ESO 8-m telescope by Castelli & Hubrig, synthetic spectra have been computed with program SMART. Notice a good fit of the observed and computed spectral line profiles of different ions. CP tähe HR 175640 vaadeldud ja programmiga SMART arvutatud spektri võrdlus ultravioletses (ülal) ja visuaalses (all) spektripiirkonnas.

From left Vasakult paremale: 2nd row Teine rida: Arved-Ervin Sapar, Jaan Pelt, Tõnu Viik. 1st row Esireas: Lili Sapar, Anna Aret

drift (LID) have been made by A. Sapar and A. Aret. The corresponding software has been composed and used to study segregation of the mercury isotopes in the chemically peculiar (CP) stellar atmospheres, finding vertical distribution of the Hg isotopes for different model data and evolutionary stages. An additional file of mercury spectral lines data, taking into account hyperfine and isotopic splitting of spectral lines has been compiled by A. Aret. The splitting of spectral lines is due to the difference in the number of neutrons in the nuclei of isotopes.

A. Sapar, A. Aret, L. Sapar and R. Poolamäe elaborated a new method to determine the chemical composition and its vertical distribution throughout the whole stellar atmosphere. The method is based on the sum of weighted spectral line profiles. The weight function is defined as the absolute value of the derivative of the residual flux relative to the logarithmic abundance of the studied chemical element. The correction to the chemical composition is thereafter found by the best fit method, applied to the difference of the similarly weighted observed and computed synthetic spectra. The proposed procedure removes automatically all spectral areas free of spectral lines of the studied elements. It also gives dominating weight to these spectral lines and their slopes which are more sensitive to the abundance of the studied chemical element. To obtain adequate results, the high-dispersion and high-precision data both for the observed and synthetic spectra are needed. In addition, high signal-to-noise ratio of the observed spectra is obligatory. The method can be named the pan-spectral or cumulative weighted line widths method.

The corresponding software has been composed and chemical composition of the CP star HR 175640, which is a typical HgMn star, has been studied (Figure 4.3). The observational spectrum obtained in Chile on the ESO 8-meter telescope with high-dispersion echelle spectrograph UVES by Castelli and Hubrig was used. The spectrum has signal-to-noise ratio 200–400, resolution 90 000–110 000 and it covers the wavelength range 300–1000 nanometers. Abundances of 12 chemical elements and general picture of their distribution in the atmosphere were determined using the proposed pan-spectral method.

The method can also be used for finding corrections to effective temperature and gravity using as the weight function the absolute value of derivative of residual flux with respect to the studied parameter.

4.5 Precataclysmic and eclipsing close binaries

From left Vasakult paremale: Vladislav-Venjamin Pustynski, Izold Pustylnik

V.-V. Pustynski and I. Pustylnik continued studies of the peculiarities of the evolutionary history of extreme horizontal branch (EHB) objects in binary systems with hot subdwarfs. These helium burning stars have masses almost exactly equal to a half of solar mass and thin practically inert hydrogen envelopes. Predominant part of all known EHB stars belong to the binary systems. V.-V. Pustynski and I. Pustylnik have found simple analytical approximating formulae for the mass loss rate during the Roche lobe filling evolutionary stage of such binaries. It turned out that for a wide range of initial separations between the components and different values of the assumed accretion rates, the mass loss rate from the binary is proportional to the luminosity of the binary and inversely proportional to the product of its total mass by the radius of donor star with power law index close to $n = 3/2$. This relation is valid as long as the donor's radius remains close to the critical Roche lobe size. The value of the index n is weakly dependent on the rate of the Roche lobe overflow and the ratio of the masses of the components.

A long-period eclipsing binary system RX Cas ($P_{\rm orb} = 32^{\rm d}.38$) has been studied by V. Harvig and I. Pustylnik based on new light curves. The earlier ones were obtained by P. Kalv and V. Harvig. The former head of Tallinn Observatory P. Kalv who investigated RX Cas between 1969 and 1993, pointed out that the intrinsic variability of this binary, belonging to the W Serpentis type interacting binary systems, is associated with the primary (more luminous) companion which fills in its Roche lobe. He found a reliable value of the period of intrinsic variability ($P_{\rm intrins} = 516^{\rm d}.06$). New $UBVR$ light curves obtained since 1993 support this value. Analysis of the *O–C* diagram is in a good accord with the earlier evidence of the period lengthening at a rate $\Delta P/P \sim 10^{-7}$ which for the conservative mass transfer implies the mass exchange rate between the components roughly equal to $10^{-6} M_\odot$ per year. Based on these results, V. Harvig and I. Pustylnik evaluated the most probable physical and orbital parameters of the progenitor of RX Cas using the formalism elaborated by V.-V. Pustynski and I. Pustylnik. They have found that the original total mass of the binary was about $12\ M_\odot$ and the initial separation of the components amounted to $345\ R_\odot$. Thus, RX Cas was formed from a wide binary system and became a close binary due to the considerable mass loss and mass transfer between the components.

I. Pustylnik, V. Harvig and T. Aas and M. Mars (Tallinn University of Technology) continued the analysis of $UBVR$ light curves of the eclipsing binary BM Cas ($P_{\rm orb} = 197^{\rm d}.275$), obtained between 1967 and 1996 in Tallinn Observatory. The authors indicated that the observed colour variations of light curves can be explained assuming that the effective temperature of the invisible secondary component is at most $T_{\rm eff2}$ =3500–4000 K and the radius of its photosphere is much smaller than that of the primary. Therefore the system looks more red in a primary minimum than in the maximum light, due to the transit of the cool secondary companion over the disc of the primary component with $T_{\rm eff1} = 8200$ K.

The observed asymmetry of the light curves can be interpreted in terms of an emission structure located on the hemisphere of an A5 supergiant facing the companion. The temperature of this hot region is about 40% higher than in the ambient photosphere. The size of the hot region was estimated and the observed asymmetry of the light curves and intrinsic variability are explained with the aid of recurrent surface flare activity. The luminosity of the primary supergiant component and the estimated position of BM Cas on the H-R diagram suggest that the binary is in a short-lived evolutionary stage of intensive mass loss. The secondary is still a main sequence star and the binary resides in a common envelope.

4.6 Symbiotic stars and related objects

From left Vasakult paremale: Mari Burmeister, Laurits Leedjärv, Alar Puss

Spectroscopic monitoring of the symbiotic binaries CH Cyg, AG Dra, Z And and EG And was continued by L. Leedjärv, K. Annuk, M. Burmeister et al. Z And which is considered to be a prototype of symbiotic stars, revealed the most interesting result: starting from late July, additional emission components of the hydrogen Balmer lines at the radial velocities of about $\pm$ 1150 km s^{-1} were found. By analogy with some other symbiotic stars, such features most likely imply bipolar jets emitted from the hot component of the symbiotic star. Ejection of bipolar jets during the outburst of Z And in 2001 was suspected from radio observations. In spite of extensive observations, signs for jets were never before detected from the optical spectra of Z And. This fact shows that there could exist different types of outbursts in the given classical symbiotic star.

Another symbiotic star AG Dra went into the strongest outburst of the last nine years in summer 2006. Unlike several earlier outbursts, observed by us, the present outburst is to be considered so called cool outburst, during which the effective temperature of the hot component decreased significantly, and high excitation emission lines (for example, He II λ 4686 Å, and Raman scattered O VI line at λ 6825 Å) almost disappeared from the spectrum of the star.

A. Puss continued to correct model calculations for the binary star VV Cep in 2006, computing emission lines profiles originating from a rotating disk. Investigations of the interacting binary star AX Mon were also continued.

4.7 Gaia mission

V. Malyuto participated in a preparatory work for the Gaia space mission (to be launched by ESA in 2011). To classify stars observed in the mission, the minimum distance method (MDM) is being developed where the astrophysical parameters (APs) are determined by averaging over the APs of the nearest neighbours. To improve the available APs for the neighbours, an intercomparison and homogenization of the APs (originated from different ca talogues) is being performed. This work on homogenization of catalogues is based on a technique of estimating the external accuracies of catalogues from data residuals which has been elaborated in Tartu by Kuzmin, Malyuto and Eelsalu in 1986. At the present stage the values of effective temperatures for the most reliable catalogues (up to 10) have been compiled and analysed, the external errors for some catalogues have been estimated by the above mentioned technique and the system of weights (inversely proportional to the external and internal errors) has been proposed to produce a homogenized catalogue of effective temperatures for many hundreds of FGK stars. This approach will be extended to other APs, too (luminosity, gravity, metallicity).

The first step to optimize the photometric system for the Gaia space telescope was finished by the publication of a comprehensive paper on the subject in 2006 in Monthly Notices of the Royal Astronomical Society. I. Kolka and V. Malyuto were amongst the co-authors of this investigation. Due to the changed design of the Gaia telescope the photometric tasks will be performed with the low resolution slitless spectrograph replacing the former method of filterband photometry. This new scheme enhances the role of emission line objects in the calibration of photometric data. The database on spectral energy distributions of emission line stars compiled by I. Kolka has been provided to the Gaia photometry coordination unit for the corresponding simulative analysis. A preliminary version of the similar database on T Tauri stars has been compiled by the bachelar student M. Kama (under supervision by I. Kolka) to be used in the assessment of classification capabilities of the Gaia photometric system in the case of these stars.

4.8 Time and frequency analysis of astronomical phenomena

J. Pelt continued to work on the lines well established already. Using new statistical methods he tried to find how it is possible to single out a non-axisymmetric component of the solar activity. The activity elements on the surface of the Sun follow general differential rotation patterns and it is very hard to detect large scale irregularities deeper inside. Some authors have obtained quite controversial results about possibility that the Sun has a kind of "face" which can be revealed by particular sophisticated statistical procedures. With colleagues from Finland and Great Britain J. Pelt tried to check the results obtained, but in vain.

Together with younger coworkers J. Pelt proceeded with statistical analysis of gravitational lens systems data. They developed a new method to estimate full time delay sets from blended photometry. In particular, they studied systems with one pure signal and bi-component blend. In the latest in-

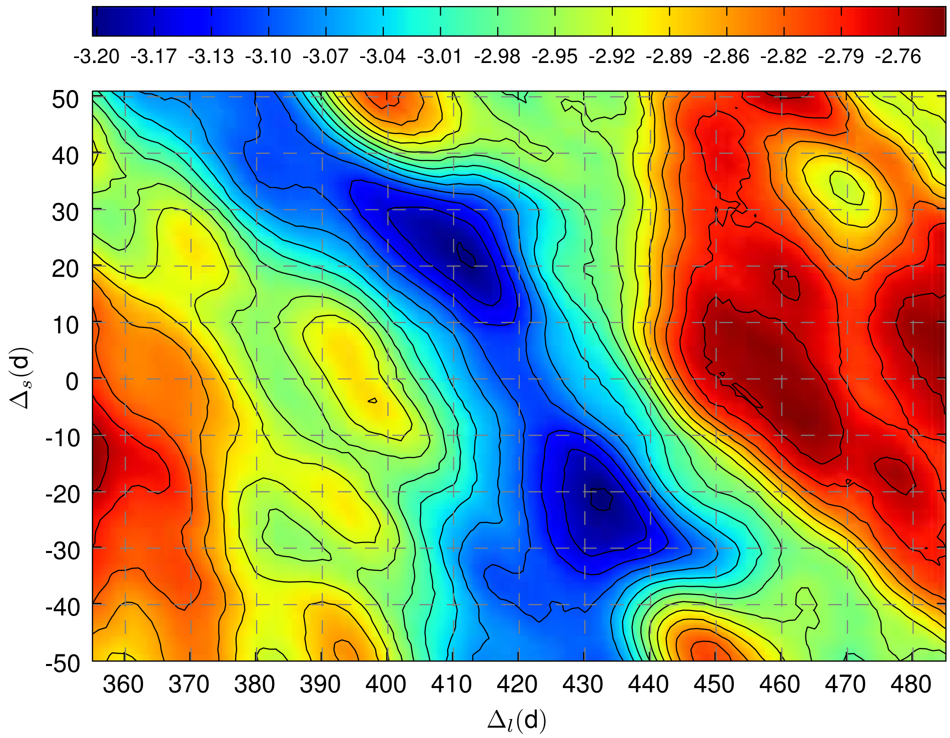


Figure 4.4: It is known, that there is a time delay between the A and B light curves of the double quasar QSO 0957+561. Using our method for estimating time delays from unresolved photometry, we were able to show, that the B curve can be disentangled into two time-shifted source curves. There are two minima in the figure, that mark two pairs of time delays we found. Long delay between A and B curves is marked as Δ_l and short delay between the components of B curve is marked as Δ_s. The two pairs of time delays are equally significant because of the degeneracy of the method. Gravitatsioonilääts tekitab kvasarist QSO 0957+561 kaks kujutist: A ja B. Nende kujutiste heleduskõverad on sarnased, kuid ajas nihutatud. Meil õnnestus näidata, et B-kõver on omakorda kahe sarnase, aga ajas nihutatud heleduskõvera summa. Miinimumid pildil tähistavad kvasari heleduskõveratest leitud ajanihete paare: Δ_l on A- ja B-kõverate vaheline pikk ajanihe, Δ_s on B-kõvera komponentide vaheline lühike ajanihe (päevades). Miinimumide dubleeritus tuleneb meetodi omadustest.

vestigations they already started to analyse systems where two bi-component blends are observed. New results can be quite useful for a long time baseline monitoring programmes with moderate resolution.

A quite new topic where J. Pelt is engaged together with students is use of so called Huang-Hilbert transforms. Currently they develop a necessary software base. It is planned to use a new methodology to analyse light curves of the young Sun-like magnetically active stars and (exceptionally) also meteorological and actinometric data. The method is promising because it allows to detect weak modulations and nonlinearities in cyclic data.

4.9 Radiative transfer

T. Viik together with N.J. McCormick (Washington University, Seattle, USA) studied the behaviour of the radiation field deep inside an atmosphere by means of numerically investigating the attenuation coefficients. The scatte ring and absorbing particles of different sizes and either spherical or randomly oriented nonspherical shape were considered.

I. Vurm and J. Poutanen (Oulu, Finland) developed a numerical code to describe radiative processes in relativistic plasmas in the vicinity of compact astrophysical objects. The relevant processes taken into account are cyclo-synchrotron emission and absorption and Compton scattering. The code can handle a wide range of particle energies, from nonrelativistic to ultrarelativistic energies for charged particles and from radio frequencies to GeV/TeV energies for radiation. A simple one-zone model is being used for describing radiative transfer. In contrast, the relevant microprocesses have been calculated as accurately as possible without making different simplifying approximations (such as the Thomson approximation or neglecting the cyclotron regime), which would render the code applicable only to certain energetic regimes.

5 Optical remote sensing of environment in Estonia and Baltic region Eesti ning Balti regiooni keskkonna optilise kaugseire alused

Atmosfäärifüüsika osakonna uurimistemaatika hõlmab nii kliima uuringuid, atmosfäärioptikat kui aluspinna uuringuid optilise kaugseire meetoditega. Arendati edasi radiomeetria seadmeparki nii UV-kiirguse kui taimkatte ja veekogude spektraalsete peegeldusomaduste mõõtmiseks.

Euroopa Liidu COST 726 projektile on tehtud soovitusi tagasiulatuva erüteemse UV kiirguse päevadooside kaardi koostamiseks kogu Euroopa kohta kuni 1950. aasta alguseni. Eestis ei küüni UV kiirguse tase ligikaudu 100 päeva vältel vitamiin D sünteesi võimaldava läveni, kuid päikese käes viibimine vajab ka meie laiuskraadil piiramist suvel, kui osutuvad võimalikuks liiga suured UV kiirguse doosid. Olukorra täpsemaks hindamiseks on kasutusel automaatne UV spektrite registreerimise süsteem, millega on 2004. aastast alates registreeritud umbes 30 000 spektrit. Seda andmestikku kasutatakse erüteemse UV-kiirguse ja vitamiini D sünteesiva kiirguse muutlikkuse uurimiseks.

Jätkus atmosfääri aerosooli omaduste ja kliima muutuste statistiliste seaduspärasuste uurimine, et selgitada kliimamuutuse võimalikkust. Atmosääri optiliste omaduste tundmine on oluline nii kiirguskliima kui satelliitkaugseire jaoks. Päikesekiirguse aegridade analüüsist selgub, et viimase 10-15 aasta jooksul on muutuste trendid vastupidised eelmistele kümnenditele, põhjuseks aerosooli hulga kahanemine ja muutused atmosfääri tsirkulatsioonis.

Eesti veekogude satelliitkaugseire usaldatavuse tagamiseks viidi läbi hulgaliselt tugimõõtmisi Peipsi järvel ja Soome lahel. Satelliidiandmed lubavad määrata vee seisundit kogu akvatooriumi ulatuses, mis ei ole võimalik kontaktmõõtmistega. Hästi õnnestub klorofülli hulga määramine. Lahustunud orgaanilise aine hulga edukaks määramiseks satelliitide optiliste mõõtmiste andmetest on vajalik täiendav uurimistöö.

Taimkatte kaugseire vallas viidi läbi nii alusuuringuid kui ka rakendati kogunenud oskusi konkreetsete praktiliste ülesannete lahendamiseks. Füüsikaliste kiirguslevimudelite teooria arendamiseks uuriti footoni uuestipõrkumise tõenäosuse rakendatavust geomeetrilis-optilistes taimkatte kiirguslevimudelites. Lisaks korrektsele matemaatilisele formuleerimisele vajavad nimetatud mudelid ka usaldusväärset informatsiooni taimkatte seesmise struktuuri kohta, mis on paraku väga raskesti mõõdetav. Seetõttu kasutatakse sageli mitmesuguseid regressioonmudeleid sidumaks kiirguslevis olulised puu võra parameetrid ja lehtede kogupindala kergemini mõõdetavate parameetritega nagu puude kõrgus, rinnasdiameeter jms.

Taoliste seoste leidmiseks ja pegeldusmudelite sisendparameetrite kontrolliks tehti mitmeid välimõõtmisi nii Eesti Maaülikooli Järvselja õppebaasis, mis on juba aastaid teeninud satelliidimõõtmiste tugialana, kui ka Tõravere energiavõsa istanduses. Satelliidipiltide interpreteerimise täpsust aitab suurendada ka vastvalminud 256-kanaliline arvutijuhitav lennukispektromeeter, millega mõõdeti Järvselja satelliidimõõtmiste (CHRIS/PROBA) katseala atmosfäärialuseid peegeldumisspektreid. Mõõtmistulemused võimaldasid korrigeerida uurimissatelliidil PROBA töötava kujutisespektromeetri CHRIS kaliibrimiskoefitsiente.

Uuriti Järvselja puistute peegeldusomaduste sesoonseid käike, primaarproduktsiooni hindamise võimalusi ning lageraiealade seiret mõjutavaid tegureid. Väljatöötatud meetodid on kasutatavad Kyoto protokolli nõuete täitmise kontrolliks. Lisaks on satelliidiinfot edukalt kasutatud Eesti maastike muutuste ja maakasutuse trendide tuvastamiseks.

In the laboratory of optical radiometry Optilise radiomeetria laboratooriumis

5.1 Solar UV radiation and atmospheric ozone

About 30 000 UV spectra have been recorded at Tõravere since 2004 using a computer aided minispectrometer Avantes AvaSpec 256. Currently a study of the reliability of calculations of the doses applying different spectral weigh ting functions is performed.

The calibration facilities available in the laboratory of optical radiometry of Tartu Observatory have been improved during 2006 thanks to using a new sertificated FEL lamp and modifications in its power supply. These measures helped to achieve improvement in the quality assurance of the local optical measurements in the UV range (U. Veismann, S. Lätt, I. Ansko, E.-M. Maasik). The laboratory of optical measurements offers calibration service also to other Estonian institutions. Currently the Enterprise Estonia supports a preliminary study of the Estonian potential users and their needs related to the development of optical laboratory facilities. The study is performed from Sept 1, 2006 to Feb 28, 2007.

The work on the Estonian climatology of the UV radiation is close to fi nishing and the most important results have been published in 2006 (K. Eerme, U. Veismann, S. Lätt). The group of remote sensing of the atmosphere is a participant in COST 726 action Long-term Changes and Climatology of UV Radiation over Europe (2004–2008). The action has a goal to elaborate appropriate methods and to reconstruct the maps of daily erythemal dose for the whole Europe back to 1950. The major COST action related activity in 2006 was a modelling exercise. Within the framework of this exercise different proxy-based statistical and theoretical methods of reconstruction of the erythemal UV doses for past years were tested and compared. The main results were presented at the international SPIE conference in Stockholm. A test reconstruction using the Tartu statistical model and Bergen (Norway) and Potsdam (Germany) data-sets has been performed (K. Eerme). The Tartu-Tõravere Meteorological Station belongs to the network of World Baseline Surface Radiation Network (BSRN) and its proxy data used for the UV dose reconstruction are among the most complete ones in Europe allowing to study the suitability of different proposed methods before the final selection of the best fitting version.

A statistical study of interannual variations of daily relative global irradiance as well as daily relative direct irradiance as the proxies for the UV doses reconstrution has been performed within different seasons for 1955–2006. Certain regularities have been found. The mutual correlation between the spring, summer, autumnal and winter totals was found to be very low. Quasicyclic features in spring and summer totals were evident and no linear trend during the whole studied period has been found (K. Eerme, A. Kallis, I. Ansko, U. Veismann).

Sufficient amounts of vitamin D are needed to keep human metabolism in required conditions. The necessary vitamin D level is supported by its synthesis in human skin due to moderate sunlight exposures. Maximum efficiency of the synthesis occurs at 297 nm but the data of regular narrow-band measurements of the UV radiation at wavelength 306 nm of the sensor CUVB1 can be used for studies of availability of the vitamin D synthesizing radiation (K. Eerme, U. Veismann, S. Lätt, I. Ansko). At the geographical latitudes above 50° there exists a period around the winter solstice, so called "vitamin D winter", when the level of short-wave UV radiation remains persistently below the threshold needed for vitamin D production. The Estonian conventional clear-sky "vitamin D winter" lasts about 100 days. Due to the lower seasonal total ozone in autumn it starts at 16.5° noon solar elevation around Nov 6 and ends at 21.5° noon solar elevation around Feb 19. The conventional here means as corresponding to the normal seasonal total ozone and atmospheric transparency. Depending on the total ozone and cloudiness the "vitamin D winter" may start up to two weeks earlier and last for another two weeks later of its conventional end. A preliminary study of the possibilities to reconstruct the availability of vitamin D synthesizing doses before and after the conventional "vitamin D winter" has been done back to 1979, i.e. for the period when satellite total ozone data are available. As the ambient UV radiation exposure leads to both beneficial and harmful health effects, the regulation of exposures is a key problem to avoid both too short and excessively long exposures.

5.2 Earth atmosphere and climate

Studies on the quantifying of non-stationarity in climatic time series are going on (O. Kärner). Together with P. Post (University of Tartu) the temporal variability of daily air flow characteristics (DAFC), calculated for the Baltic Sea area are studied. Changes in the statistical characteristics of the series increments appear to be similar to those for the surface air temperature increments, showing weaker non-stationarity while the increment range increases. This property may enable one to use simple empirical models for describing their temporal variability. A manuscript on the revealed results was submitted for publication to the journal Environmetrics.

V. Russak has analysed optical properties of aerosol measured by a spectral photometer Cimel Electronique 318A at Tõravere in 2002–2004. In the spectral area of 440–1020 nm atmospheric aerosol at Tõravere is mainly acting as a diffuser of solar radiation. During the summer–months the diffusion constitutes about 80 % from the total extinction. The role of diffusion decreases in August-September. The diffusion by the fine aerosol (r = 0.05–0.6 μm) decreases with the increase of the wavelength of the radiation, while for coarse particles an opposite relationship is characteristic.

Two different periods have become evident in the time series of solar radiation measured at Tartu-Tõravere Meteorological Station: the period from 1955 to the beginning of the 1990s was characterized by a decrease in global and direct solar radiation, as well as in atmospheric transparency of cloud-free atmosphere and by an increase in low cloudiness, while opposite trends have become evident during more recent years. According to the proposal of the BALTEX Secretariat (The European Continental-Scale Experiment of the Global Energy and Water Cycle Experiment within the World Climate Research Programme), V. Russak together with J. Jaagus (University of Tartu) analysed long-term changes in cloudiness, sunshine duration and components of radiation balance, and their territorial peculiarities in the Baltic Sea catchment basin. The results of this analysis will constitute a part of the book "BALTEX Assessment of Climate Change for the Baltic Sea Basin". The first version of the manuscript has been finished.

From left Vasakult paremale Silver Lätt, Ilmar Ansko, Viivi Russak, Uno Veismann, Anu Reinart, Olavi Kärner. Sitting Istub: Kalju Eerme

5.3 Remote sensing of water bodies

Main topic of activities was related to validation of MERIS/Envisat (ESA) latest reprocessing results. ESA finished new reprocessing in March and opened data archives for validation and tests. For collections of *in situ* data we have participated in several field campaigns, organized in collaboration with Marine Systems Institute (Tallinn University of Technology) and Marine Institute (Tartu University). Thanks for work of doctoral students (I. Ansko and S. Lätt) new measurement system was tested and used during Lake Peipsi field campaigns. TriOS Optical Sensors measurement system, which includes three hyperspectral radiometers (one for incident irradiance, one for sky radiance and one for water leaving radiance) enables validation of ocean colour satellite products also during continued measurements from moving ship.

For analysis of MERIS 2nd reprocessing (K. Alikas, A. Reinart) altogether 279 images over large European lakes (Peipsi, Vänern and Vättern) were used. Results are best for L. Peipsi. MERIS Case II processing resulted in invalid reflectance over the lakes as indicated by flag PCD-1-13, and invalid Case II products (concentration of chlorophyll, suspended sediments and absorption by CDOM – Coloured Dissolved Organic Matter) for 70–90% of cases in L. Vänern, for 90–100% in L. Vättern and for only 5–47% in L. Peipsi. Nevertheless, many features in the spatial distribution of optical properties can be observed (differences in lakes, plankton bloom, river plumes).

On the basis of the MERIS Level 2 RR data we were able to conclude that the MERIS Case II chlorophyll concentration product (*algal*-2) and the *in situ* measured CChl correlate ($R2$=0.52), and the values look reasonable. The MERIS results make a clear difference between the three studied lakes – L. Peipsi has the highest and L. Vättern the lowest values; development of a seasonal variation (bloom) can be detected. The MERIS still underestimates very high chlorophyll values during autumn bloom in L. Peipsi (>45 mg m^{-3}) and underestimates values in L. Vänern and L. Vättern about twice. For suspended sediment and CDOM product there were no correlations between the MERIS and measured data. The product *total–susp* still gives a reasonable spatial distribution for most of the lakes area (excluding the coastal region of L. Vänern).

Absorption by CDOM is strongly underestimated in L. Vänern and Peipsi. Validation of the MERIS product over lakes should continue including the validation of relationships between optically active substances and inherent optical properties. However, it is most critical to improve atmospheric correction over lakes, and receive valid reflectance input for the Case II processing.

K. Valdmets participated in field cruise of the Vrije Universiteit, Amsterdam, to complement database for inherent optical properties, needed for development of optical classification of coastal and lakes waters. Turbid waters of North Sea coastal regions and Waddenzee are comparable with L. Peipsi during heavy bloom (Secchi transparency 0.5 m), while in clearest waters (Secchi 6 m) water transparency exceeds common values measured in Gulf of Finland (2–4 m).

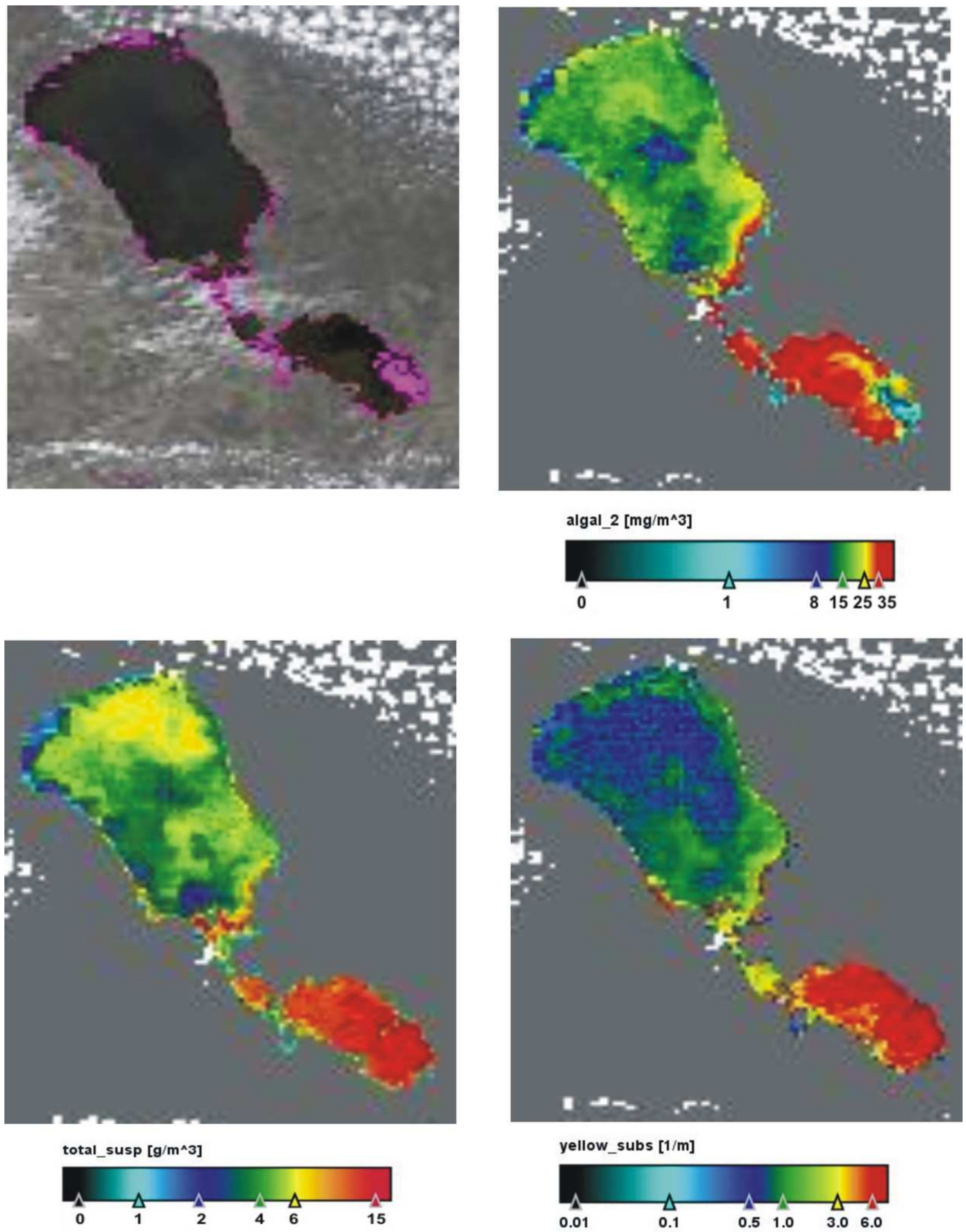


Figure 5.1: Water quality products and Flagged areas (purple) over L. Peipsi (8 May 2003) on MERIS RR-L2 images. Flags are used to detect and mark areas which are out of the algorithm training range. Vee parameetrid (klorofüll ja hõljum, lahustunud orgaaniline aine) ja märgendatud piirkonnad Peipisi järve MERIS RR-L2 pildil (8. mai 2003). Märgendiga (lilla) tähistatakse piirkondi, kus satelliidipildi töötlus pole õnnestunud.

5.4 Remote sensing of vegetation

Theoretical investigations on the compatibility of the photon recollision probability theory with a geometric-optical model of radiative transfer in vegetation were carried out. Photon recollision probability in plant canopies is defined as the probability that a photon, after having survived an interaction with a canopy element, will interact again. This probability can be considered spectrally invariant and is a useful tool for relating the solutions of the radiative transfer problem at different wavelengths. It was shown that the two physically-based concepts are compatible and crown-level clumping in plant canopies increases photon recollision probability. The concept of photon recollision probability has been previously studied to parameterize shoot-level clumping in canopy reflectance models. Clustering of conifer needles into shoots enhances absorption of intercepted radiation due to an increase in photon recollision probability. Crown-level clumping described by geometric-optical models, despite a different geometry, produces a similar effect on a much larger scale.

The seasonal course of reflectance was calculated by means of the Kuusk-Nilson forest reflectance model for fertile and infertile birch and pine forests, spruce forests and Pinus bog. The results of simulation were compared to the respective seasonal courses derived from the time series of Landsat and SPOT satellite images. The comparisons showed a rather good qualitative agreement, however, with some quantitative differences. The most important driving factors causing the seasonal course of reflectance, occured to be the seasonal changes in tree layer and grass/dwarf shrub layer green leaf area index, course of sun angle during the season, and, as some surprise, change of surface (soil+litter) moisture, especially in early spring and autumn. To explain the convex seasonal courses of low canopy cover Pinus bogs, it is not sufficient to only consider the effect of sun angle change. Evidently, the ground vegetation together with the bog surface should have the convex seasonal reflectance curves as well. On mineral soils, typical seasonal reflectance curves of the understorey are concave in the visible part of the spectrum, as caused by the maximum of green leaf area index and of amount of chlorophyll in midsummer. It was found that for a selection of forest types from Järvselja, an acceptable ($R2 = 0.83$) linear relation exists between the seasonal average of the NDVI (Normalised Difference Vegetation Index) as derived from the time series of satellite images and wood mass increment as estimated from the forest database of Järvselja. This fact gives us a hope that the methods of satellite remote sensing are applicable for estimating the primary productivity of Estonian forests to monitor the fulfilment of requirements of the Kyoto protocol.

A series of tests was carried out by M. Lang to test the applicability of published tree crown radius and foliage mass models in forming the input of a forest reflectance model. The study was based on the detailed forest inventory data from forest growth plots (A. Kiviste, M. Hordo, Estonian University of Life Sciences), three Landsat-7 ETM+ images and the database of forest understorey reflectance spectra. Measured gap fraction data from ten forest growth plots were analysed using the Nilson-Kuusk's inversion method. The results showed that at the moment the available regression models for crown radius and foliage mass estimation are not suitable for reflectance simulation experiments in Estonian forests.

Figure 5.2: Forests at Järvselja. Järvselja metsad.

Reflectance spectra of several forest stands at Järvselja test site in the CHRIS/Proba scene of July 10, 2005 were measured on board a helicopter on July 26, 2006 (A. Kuusk, J. Kuusk, M. Lang). J. Kuusk designed a computer-controlled airborne spectrometer. The heart of the spectrometer is the 256 band NIR enhanced miniature spectrometer MMS-1 by Carl Zeiss Jena GmbH. The spectrometer is controlled by an Atmel microcontroller ATmega88. The fore-optics restricts the field-of-view to 2°. In addition to spectrometer the measuring system incorporated Logitech QuickCam Messenger web camera and Magellan SporTrak Pro GPS. The spectrometer was mounted at the chassis of a Robinson R-22 helicopter looking vertically. Data from the spectrometer were collected by a laptop PC 3–5 times per second, and from the web camera and a Magellan SporTrak GPS receiver once per second. Measurements were done from the height of 100 m above ground level. Each recorded spectrum was digitally recorded onto the CHRIS image, the accuracy of determining locations was checked by comparing web camera images to registered aerial photographs provided by Estonian Land Board. Reflectance spectra were collected for 209 stands.

From left Vasakult paremale: 2nd row Seisavad: Tõnu Prans, Matti Pehk, Tiit Nilson, Madis Sulev, Joel Kuusk, Mait Lang, Matti Mõttus, Andres Kuusk, Urmas Peterson. 1st row Istuvad: Miina Rautiainen, Sandra Suviste, Krista Alikas

Atmospheric correction of the CHRIS images was performed in two stages. First, with the 6S atmospheric RT model a look-up-table (LUT) of top-of-atmosphere (TOA) radiances was generated varying ground vegetation parameters in model simulations. The multispectral homogeneous canopy reflectance model served as the underlaying surface in the 6S model. In simulations the measured atmosphere parameters were used. The created LUT was approximated by a second order polynomial separately for every CHRIS band. The approximation polynomials were used for the calculation of top-of-canopy reflectance using the TOA radiance measured by CHRIS. Second, the adjacency effect was corrected by 2-D deconvolution. The point spread function (PSF) of the atmosphere was estimated using radiance of small water bodies in red spectral bands. Atmospherically corrected CHRIS reflectance values have good agreement with airborne data in visible spectral bands. The NIR bands of the CHRIS imaging spectrometer seem to have some calibration problems.

U. Peterson together with A. Kiviste and J. Budenkova (Estonian University of Life Sciences, Institute of Forestry and Rural Engineering) estimated the influence of clearcut patch variables: patch size, patch shape and growing conditions on forest clearcut classification results on medium resolution Landsat Thematic Mapper winter images. The threshold level separating the forest clearcuts from the non-changed areas on a difference image of a two-date image pair was defined to match the total area of the classified clearcuts from the satellite image to the total area of clearcuts defined in the forestry database. The analysis showed that a major effect on the classification results was caused by the factors like: ″the mean of the clearcut pixel values on a difference image″ and ″the relative number of clearcut boundary pixels with forest". Factors like ″the relative number of clearcut boundary pixels with coniferous forest″ and ″the ratio of clearcut area to clearcut perimeter″ had a statistically significant but relatively minor influence on classification results. The age of a clearcut, time in years passed since clearcut logging and the site type group had no significant influence on classification results. The relationships were evident in all Landsat TM bands of the visible and near infrared spectral region.

5.5 Structure model for alder stand

In 2006, M. Mõttus and M. Sulev continued the work on improving the structure model of the gray alder (*Alnus incana*) stand in Tõravere. The aim of the model is to produce input parameters for forest radiative transfer models allowing to estimate the accuracy of the abstractions and simplifications used in such mo dels and to assess their influence on model outputs. The structure model describes the plants as fractal structures. As a simplification, growth dynamics is excluded, so the model is only valid at the moment of the measurements. Thus, the model is based on growth orders, but the geometrical dimensions (length, diameter) of the growth orders is fixed at their mid-summer values. After mid-summer, the development of the stand was slow and this approximation can be considered reasonably accurate. A total of six growth orders was determined in 2006, from the stem (order 0) to the leaves (order 5). First-order branches are the lowest branches attached

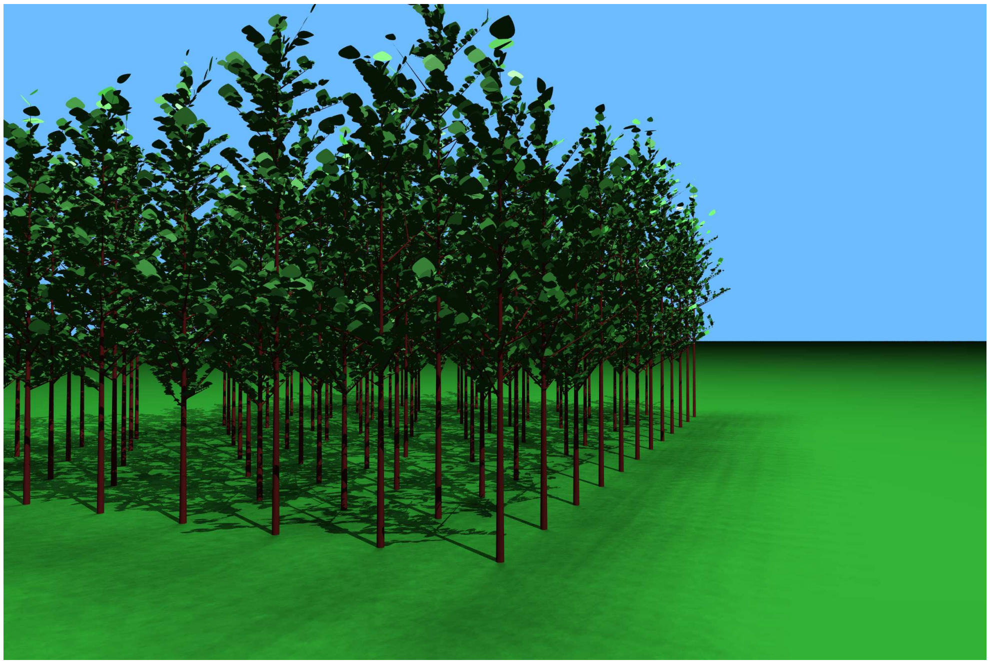


Figure 5.3: A raytraced image of an alder stand generated by the structure model. Statistilise struktuurimudeli poolt genereeritud lepavõsa.

to the stem, the development of which started during the first growing year; second-order branches can be attached both to the first-order branches or directly to the stem above the first-order branches, etc. Leaves are attached either to the branches of the highest order (order 4) or the highest-order segments of lower-order branches. However, the six growth orders can not be directly linked to growing years as their number is smaller than the age of the stand in years. For example, during the last two years, the number of growth orders has only increased by one.

The measurement scheme was modified in 2006 to take into account the shortcomings in statistical samples obtained during the previous years. Thus, a representative sample of both the geometric dimensions and the branching structure of various growth orders was obtained using a hierarchical sampling scheme. The modified scheme also allowed us to reduce the required measurement effort. The measurements were carried out from the beginning of July until mid-August.

To evaluate the performance of plant canopy radiative transfer models, various radiation measurements were carried out: the spectral reflectance and transmittance of leaves and ground reflectance was measured using a FieldSpec spectrometer (ASD, Inc.). Simultaneously with the biometrical measurements, several characteristics of the radiation field both inside and above the alder stand were measured using the FieldSpec spectrometer and a CCD radiometer constructed in Tartu Observatory. These measurements allowed us to characterize the spectral and angular signatures of radiation transmitted and reflected by the canopy. Additionally, a carriage moving along a six-meter-long aluminium bar was equipped with broadband sensors to record the spatial variation of the radiation field. Incident radiation was measured at the nearby actinometrical station of Estonian Meteorological and Hydrological Institute and by a sun photometer operated by the NASA AERONET network.

6 Publications Publikatsioonid

6.1 Papers in scientific journals and books Artiklid teadusajakirjades ja -kogumikes

6.1.1 Astronomy Astronoomia

Annuk K.: Digitizing Old Photographic Plates and Data Archiving at Tartu Observatory. *PDPP Newsletter No. 4*, 17, 2006.

Einasto J., Einasto M., Saar E., Tago E., Liivamägi L. J., Jõeveer M., Suhhonenko I., Hütsi G., Jaaniste J., Heinämäki P., Müller V., Knebe A., Tucker D.: Luminous Superclusters: Remnants from Inflation? *Astron. Astrophys. 459, L1–L4*, 2006.

Haud U., Kalberla P.M.W.: Gaussian Decomposition of H I Surveys. II. Separation of Problematic Gaussians. *Baltic Astronomy 15*, 413–433, 2006.

Hirv A., Annuk K., Eenmäe T., Liimets T., Pelt J., Puss A., Tempel M.: Orbital Elements and Mass-Loss Rate of V444 Cygni. *Baltic Astronomy 15*, 405–412, 2006.

Hütsi G.: Clustering of SZ Clusters on a Past Light-Cone: Acoustic Oscillations and Constraints on Dark Energy. *Astron. Astrophys. 446*, 43–60, 2006.

Hütsi G.: Acoustic Oscillations in the SDSS DR4 Luminous Red Galaxy Sample Power Spectrum. *Astron. Astrophys. 449*, 891–902, 2006.

Hütsi G.: Power Spectrum of the SDSS Luminous Red Galaxies: Constraints on Cosmological Parameters. *Astron. Astrophys. 459*, 375–389, 2006.

Jordi C., Hog E., Brown A.G.A., Lindegren L., Bailer-Jones C.A.L., Carrasco J.M., Knude J., Straizys V., de Bruijne J.H.J., Claeskens J.-F., Drimmel R., Figueras F., Grenon M., *Kolka I.*, Perryman M.A.C., Tautvaisiene G., Vansevicius V., Willemsen P.G., Bridzius A., Evans D.W., Fabricius C., Fiorucci M., Heiter U., Kaempf T.A., Kazlauskas A., Kucinskas A., *Malyuto V.*, Munari U., Reyle C., Torra J., Vallenari A., Zdanavicius K., Koraktis R., Malkov O., Smette A.: The Design and Performance of the Gaia Photometric System. *Mon. Not. Royal Astr. Soc. 367*, 290–314, 2006.

Kalberla P.M.W., *Haud U.*: Global Properties of the H I High Velocity Sky – A Statistical Investigation Based on the LAB Survey. *Astron. Astrophys. 455*, 481–498, 2006.

Klochkova V.G., *Kipper T.*: Optical Spectroscopy of the Post-AGB Star CGCS 6857=IRAS 20000+3239, *Baltic Astronomy 15*, 395–404, 2006.

Leedjärv L.: Symbiotic Stars in the Context of Binary Evolution and Metallicity. *Astrophysics and Space Science 304*, 105–107, 2006.

Pelt J., Brooke J.M., Korpi M.J., Tuominen I.: Kinematic Frames and "Active Longitudes": does the Sun have a Face? *Astron. Astrophys. 460*, 875–885, 2006.

Pustylnik I.: VIIIth General Meeting of Euro-Asian Astronomical Society. *Astronomical and Astrophysical Transactions 24*, 459–462, 2005.

Pustynski V.-V., Pustylnik I.: On the Peculiarities of Evolutionary History of EHB Objects in Binary Systems with Hot Subdwarf Companions. *Acta Astronomica 56*, 83–95, 2006.

Pustynski V.-V., Pustylnik I.: Hot Subdwarfs in Precataclysmic Binaries. *Astrophysics and Space Science 304*, 265–268, 2006.

Sapar A., Poolamäe R., Sapar L.: High-Precision Approximation Expressions for Line Profiles of Hydrogenic Particles. *Baltic Astronomy 15*, 435–447, 2006.

Tago E., Einasto J., Saar E., Einasto M., Suhhonenko I., Jõeveer M., Vennik J., Heinämäki P., Tucker D.: Clusters and Groups of Galaxies in the 2dF Galaxy Redshift Survey: A New Catalogue. *Astron. Nach. 327*, 365–378, 2006.

Tamm A., Tenjes P.: Surface Photometry and Structure of High Redshift Disk Galaxies in the HDF-S NICMOS Field. *Astron. Astrophys. 449*, 67–78, 2006.

Tempel E., Tenjes P.: Line-of-Sight Velocity Dispersions and a Mass-Distribution Model of the Sa Galaxy NGC 4594. *Mon. Not. Royal Astr. Soc. 371*, 1269–1279, 2006.

6.1.2 Atmospheric physics Atmosfäärifüüsika

Arst H., Erm A., Leppäranta M., *Reinart A.*: Radiative Characteristics of Ice-Covered Freshwater and Brackish Water Bodies. *Proc. Estonian Acad. Sci. Geology 55*, 3–24, 2006.

Eerme K., Veismann U., Lätt S.: Proxy-Based Reconstruction of Erythemal UV Doses Over Estonia for 1955–2004. *Ann. Geophys. 24*, 1767–1782, 2006.

Eriksson H.M., Eklundh L., *Kuusk A., Nilson T.*: Impact of Understory Vegetation on Forest Canopy Reflectance and Remotely Sensed LAI Estimates. *Remote Sensing of Environment 103*, 408–418, 2006.

Kuusk A., Paas M.: Radiometric Correction of Hemispherical Images. *ISPRS Journal of Photogrammetry & Remote Sensing* [doi:10.1016/j.isprsjprs.2006.10.005], 2006.

Lang M., Jürjo M., Adermann V., Korjus H.: Integrated Approach for Quantitative Assessment of Illegal Forest Fellings in Estonia. *Baltic Forestry 12*, 103–109, 2006.

Lang M., Lükk T., Rähn A., Sims A.: Kasvukäiguproovitükkide kaugseire võimalusi. *Metsanduslikud Uurimused (Forestry Studies) 43*, 24–37, 2006.

Liira J., Püssa K., *Peterson U.*: The Radiance Contrast of Forest-to-Clearcut Edges on a Medium Resolution Landsat Enhanced Thematic Mapper Satellite Winter Image. *International Journal of Remote Sensing 27*, 2753–2766, 2006.

Mõttus M., Sulev M.: Radiation Fluxes and Canopy Transmittance: Models and Measurements inside a Willow Canopy. *Journal of Geophysical Research 111(D02109)*, 1–11, 2006.

Mõttus M., Sulev M., Lang M.: Estimation of Crown Volume for a Geometric Radiation Model from Detailed Measurements of Tree Structure. *Ecological Modelling 198*, 506–514, 2006.

Paavel B., Arst H., *Reinart A.*, Herlevi A.: Model Calculations of Diffuse Attenuation Coefficient Spectra in Lake Waters. *Proc. Estonian Acad. Sci. Biology, Ecology 55*, 61–81, 2006.

Rautiainen M., Stenberg P., *Mõttus M.*: Lehtialaindeksin kaukokartoituksesta. *Metsätieteen aikakauskirja – Folia Forestalia 3*, 411–415, 2006.

Reinart A., Kutser T.: Comparison of Different Satellite Sensors in Detecting Cyanobacteria Bloom Event in the Baltic Sea. *Remote Sensing of Environment 102*, 74–85, 2006.

Reinart A., Pedusaar T.: Reconstruction of the Time Series of the Underwater Light Climate in a Shallow Turbid Lake. *Aquatic Ecology*, DOI 10.1007/s10452-006-9056-0, 2006.

Reinart A., Pärn O.: Ice Conditions of the Large Shallow Lake (Lake Peipsi) by the Observations, Ice Model and Satellite Images. *Proc. Estonian Acad. Sci. Biology, Ecology 55*, 243–261, 2006.

Wang K., Leppäranta M., *Reinart A.*: Modeling Ice Dynamics in Lake Peipsi. *Verh. Internat. Verein. Limnol. 29*, 1443–1446, 2006.

6.2 Conference papers Artiklid konverentsikogumikes

6.2.1 Astronomy Astronoomia

Alamo-Martínez K., Andernach H., Coziol R., *Tago E.*: Dynamics and Ellipticities of Brightest Cluster Galaxies. In: *Revista Mexicana de Astronomia y Astrofisica: XI IAU Regional Latin American Meeting of Astronomy, Pucon, Chile, December 12–16, 2005,* eds. L. Infante, M. Rubio. 186, 2006.

Andernach H., Alamo-Martínez K., Coziol R., *Tago E.*: Dynamics and Shape of Brightest Cluster Galaxies. In: *ESO Astrophysics Symposia, ESO conference "Groups of Galaxies in the Nearby Universe", Santiago, Chile, December 05–09, 2005,* eds. I. Saviane, V. Ivanov, J. Borissova, Springer-Verlag, 2 pp., 2006.

Einasto J., Saar E.: The End of the Dark Age and the Formation of the Structure of the Universe. In: *Stellar Evolution at Low Metallicity: Mass Loss, Explosions, Cosmology. Tartu, August 15–19, 2005*, eds. H.J. Lamers, N. Langer, T. Nugis and K. Annuk, *ASP Conf. Series 353*, 329–338, 2006.

Heinämäki P., *Suhhonenko I., Saar E., Einasto M., Einasto J.,* Virtanen H.: Light-Cone Simulations: Evolution of Dark Matter Haloes. In: *Stellar*

Evolution at Low Metallicity: Mass Loss, Explosions, Cosmology. Tartu, August 15–19, 2005, eds. H.J. Lamers, N. Langer, T. Nugis and K. Annuk, *ASP Conf. Series 353*, 381–382, 2006.

Kalv P., *Harvig V.*, Aas T., *Pustylnik I.*: On the Nature of Asymmetry of the Light Curves of BM Cas – a Long Period Eclipsing Binary. In: *Proceedings of International Conference "Variable Stars 2005"*, ed. I. Usenko, *Odessa Astronomical Publications 18*, 61–64, 2006.

Malyuto V.: Estimation of Stellar Astrophysical Parameters with the Gaia Baseline Photometric System. In: *Stellar Evolution at Low Metallicity: Mass Loss, Explosions, Cosmology. Tartu, August 15–19, 2005*, eds. H.J. Lamers, N. Langer, T. Nugis and K. Annuk, *ASP Conf. Series 353*, 401–402, 2006.

Nugis T.: Optically Thick Wind Models of WNE Stars: the Dependence of Mass Loss on Metallicity. In: *Stellar Evolution at Low Metallicity: Mass Loss, Explosions, Cosmology. Tartu, August 15–19, 2005,* eds. H.J. Lamers, N. Langer, T. Nugis and K. Annuk, *ASP Conf. Series 353*, 181–185, 2006.

Nugis T., Annuk K., Hirv A.: Observational Evidences for the Dependence of WNE-star Mass Loss on Metallicity. In: *Stellar Evolution at Low Metallicity: Mass Loss, Explosions, Cosmology. Tartu, August 15–19, 2005,* eds. H.J. Lamers, N. Langer, T. Nugis and K. Annuk, *ASP Conf. Series 353*, 193–195, 2006.

Pustylnik I.: Paleoastronoomilised ja geofüüsikalised andmed globaalsete kliima muutuste kohta ning nende mõju inimorganismile. In: International Conference *"Human Awareness and Behavior in a Changing World", Tallinn, October 14–15, 2004,* 93–98, 2006.

Pustynski V.-V., Pustylnik I.: On the Peculiarities of Evolutionary History of EHB Objects in Binary Systems with Hot Subdwarf Companions. In: *Stellar Evolution at Low Metallicity: Mass Loss, Explosions, Cosmology. Tartu, August 15–19, 2005*, eds. H.J. Lamers, N. Langer, T. Nugis and K. Annuk, *ASP Conf. Series 353,* 149–151, 2006.

Pustylnik I.: Does Modern Astrophysics Widen the Horizons of Archaeoastronomy? In: *Proceedings of the SEAC "Cosmic Catastrophes"*, eds. M. Kõiva, I. Pustylnik and L. Vesik, 145–150, 2005.

Vennik J., Tago E.: Photometric and Kinematical Study of Nearby Groups of Galaxies Around IC 65 and NGC 6962. In: *ESO Astrophysics Symposia, ESO conference "Groups of Galaxies in the Nearby Universe", Santiago, Chile, December 05–09, 2005,* eds. I. Saviane, V. Ivanov, J. Borissova, Springer-Verlag, 2 pp., 2006.

6.2.2 Atmospheric physics Atmosfäärifüüsika

Eerme K.: Põhilised kliimamuutusi mõjutavad faktorid Põhja-Euroopas ja Eestis. Major Factors Influencing Climate in Northern Europe and Es-

tonia. In: International Conference *"Human Awareness and Behavior in a Changing World"*, Tallinn, October 14–15, 2004, 149–153, 225–226, 2006.

Eerme K., Veismann U., Ansko I., Lätt S.: Year-to-Year Variations of the Vitamin D Synthesis Related UV-B Radiation in Estonia in Autumn and Spring. In: *Proc. of SPIE. Remote Sensing of Clouds and the Atmosphere 6362*, paper 16, 1–7, 2006.

Koepke P., DeBacker H., Bais A.F., Curylo A., *Eerme K.*, Feister U., Johnsen B., Junk J., Kazantzidis A., Krzyscin J., Lindfors A., Olseth J.A., den Outer P., Pribullova A., Schmalwieser W. A., Slaper H., Staiger H., Verdebout J., Vuillemier L., Weihs P.: Modeling Solar UV Radiation in the Past: Comparison of Algorithms and Input Data. In: *Proc. of SPIE. Remote Sensing of Clouds and the Atmosphere 6362*, paper 15, 1–11, 2006.

Metsamaa L., Kutser T., *Reinart A., Alikas K.*: Evaluation of the MERIS Algal Products in Optically Complex Waters. In: *Proceedings of 13th Australasian Remote Sensing and Photogrammetry Conference*, 1–4, 2006.

Nilson T., Suviste S., *Lükk T.*, Eenmäe A.: Seasonal Reflectance Course of Some Forest Types in Estonia as Determined from a Series of Landsat TM and SPOT Images and via Simulation. In: *2nd International Symposium Recent Advances in Quantitative Remote Sensing, September 25–29, 2006, Torrent (Valencia) Spain*, Abstract Book, 70–71, 2006.

Nilson T., Suviste S., *Lükk T.*, Eenmäe A.: Seasonal Reflectance Course of Some Forest Types in Estonia as Determined From a Series of Landsat TM and SPOT Images and via Simulation. In: *Second Recent Advances in Quantitative Remote Sensing*, ed. J. A. Sobrino, *Servicio de Publicaciones. Universitat de Valencia. Valencia*, 272–277, 2006.

Ohvril H., Neiman L., Teral H., Tee, M., *Russak V.*, Okulov O., *Kallis A.*, Abakumova G., Terez E., Gushchin G., Terez G., Olmo F.J., Alados-Arboledas L., Laulainen N.: Multi-Annual Variability of Atmospheric Transparency in Some European Locations. In: *Conference on Visibility, Aerosols, and Atmospheric Optics. Vienna, September 3–6, 2006*, Abstracts, 66, 2006.

Peterson U., Liira J., Budenkova J., Kiviste A.: Forest Cover Changes Since Mid-1980s in the Eastern Baltic Region, Evaluated with Multitemporal Landsat Imagery. In: *Patterns and Processes in Forest Landscapes. Consequences of Human Management. Proceedings of the 4th Meeting of IUFRO Working party 8.10.03, September 26–29, 2006, Locorotondo, Bari, Italy*, eds. R. Lafortezza and G. Sanesi. *Academia Italiana di Science Forestali, Firenze*, 393–397, 2006.

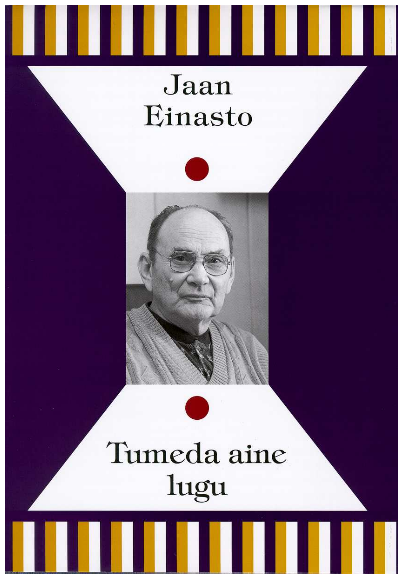
Rautiainen M., *Mõttus M.*, Stenberg P.: Physically-Based Parameterization of the Reflectance of Coniferous Stands. In: *Proceedings International Workshop 3D Remote Sensing in Forestry Vienna, February 14–15, 2006,* eds. T. Koukal and W. Schneider, 141–144, 2006.

Russak V.: Changes in Solar Radiation in Estonia During the Last Half-Century. In: *Sixth Annual Meeting of the European Meteorological Society (EMS) / Sixth European Conference on Applied Climatology (ECAC). EMS Annual Meeting Abstracts 3,* CD-ROM, ISSN 1812–7053, 2006.

Smirnov A., Holbe B.N., Panchenko M.V., Sakerin S.M., Aculinin A.A., Chubarova N.Y., *Kärner O.*, Chaikovsky A.P., Sukhinin A.I., Pavlov V.Y., Kopelevich O.V., Radionov V.F., Korotayev G.K.: Aerosol Robotic Network activity in Russia, Moldova, Estonia, Belarus, and Ukraine – as an Example of the Mutually Beneficial Collaborative Effort – Results and Prospective. In: *International Symposium on Atmospheric Radiation (MCAP-2006), St.Petersburg, Russia, June 27–30, 2006*.

6.3 Popular Articles Aimeartiklid

20. detsembril 2006 esitles akadeemik Jaan Einasto oma raamatut ”Tumeda aine lugu”, mille andis Eesti Mõtteloo sarjas välja kirjastus ”Ilmamaa”. 528-leheküljelise raamatu koostaja oli Mihkel Jõeveer, saatesõna ”Kuhu kõik need lilled jäid...” kirjutas Enn Saar. Raamatusse on koondatud populaarteaduslikke ja publitsistlikke artikleid aastaist 1974–2001, ligi poole raamatu mahust moodustab aga originaalne mälestustelugu ”Per aspera ad astrum”.



On December 20, 2006 Academician Jaan Einasto presented his book ”Story of Dark Matter”, published by the ”Ilmamaa Publischers”. This book (528 pp.) compiles popular scientific and publicistic papers by the renowned scientist from 1974 to 2001, but first of all, original story ”Per aspera ad astrum”, reflecting personal and scientific life of Jaan Einasto.

6.3.1 Astronomy Astronoomia

Einasto J., Einasto M.: See mõistatuslik kõiksus. *Eesti Aastaraamat 2006–2007*, Koost. J. Kivi, Tallinn, Euroinformer: Euroülikool, 323–351, 2006.

Einasto J.: Mihkel Jõeveer. In Memoriam. *Tähetorni Kalender 2007*, 43–45, 2006.

Einasto J.: Aksel Kipper 100 – Grigori Kuzmin 90. *Tähetorni Kalender 2007*, 46–52, 2006.

Einasto M.: Caroline Herschel ja tema vennad. *Tähetorni Kalender 2007*, 81–87, 2006.

Jaaniste J., Eenmäe T.: Diplom Rahvusvaheliselt Astronoomiaolümpiaadilt. *Tähetorni Kalender 2007*, 88–90, 2006.
Jaaniste J.: Astronoomiahuviliste 11. kokkutulek. *Tähetorni Kalender 2007*, 91–92, 2006.
Kolka I.: Mõistatuslik V838 Monocerotis. *Tähetorni Kalender 2007*, 72–76, 2006.
Kolka I.: Maailmaruum röntgenteleskoopide vaateväljas. *Horisont 3*, 32–39, 2006.
Leedjärv L.: Rändurina kõiksuses. *Lehed ja Tähed 2006*. Koost. I. Rohtmets, MTÜ Loodusajakiri, Tallinn, 108–117, 2006.
Leedjärv L.: Tähed – nähtava Universumi peamised ehituskivid. *Teadusmõte Eestis. Täppisteadused*. Koost. I. Koppel ja P. Saari, Eesti Teaduste Akadeemia, Tallinn, 21–28, 2006.
Leedjärv L.: Mida otsib Eesti kosmosest? *Horisont 6*, 8–9, 2006.
Leedjärv L.: Saadikuks Magellani Pilve. *Eesti Loodus 7*, 51, 2006.
Leedjärv L.: Astronoomide tippkohtumine Prahas. *Tähetorni Kalender 2007*, 56–60, 2006.
Leedjärv L.: Ira Saar. In Memoriam. *Tähetorni Kalender 2007*, 95, 2006.
Leedjärv L.: Universum Inimeses ja Inimene Universumis. *Inimteadvus ja käitumine muutuvas maailmas. Rahvusvaheline konverents, 14–15 oktoober 2004, Tallinn*, 141–147, 2006.
Leedjärv L.: Kuplid Tõravere mäel. *Meie Meeri*. Koost. A.-A. Marand, Meeri Küla Arendamise Selts, Nõo, 327–332, 2006.
Ruusalepp M.: Stellaarium – koht kus vestelda astronoomiast. *Tähetorni Kalender 2007*, 77–80, 2006.
Saar E., Einasto J.: Kosmoloogia uues Eestis. *Teadusmõte Eestis. Täppisteadused*. Koost. I. Koppel ja P. Saari, Eesti Teaduste Akadeemia, Tallinn, 9–19, 2006.
Sapar A., Sapar L.: UV-kiirguse uuringud kui kosmosekriminalistika. *Horisont 1*, 36–43, 2006.
Tago E.: Sündmusi astronoomias 2005. *Vaatleja 1*, 2006.
Tago E.: On see komeet või asteroid. I ja II. Milline on oht Maale langeda? *Vaatleja 2*, 2006.
Tago E.: Päikesevarjutus 29. märtsil Tähetornis ja mujal. *Vaatleja 2*, 2006.
Tago E.: Universumi reliktkiirgus on kaardistatud. II. Kolm aastat WMAP vaatlusi. *Vaatleja 2*, 2006.
Tago E.: Heledaim supernoova sai 1000 aastaseks. *Vaatleja 3*, 2006.
Tago E.: Astronoomia tippsündmusi aastail 2005–2006. *Tähetorni Kalender 2007*, 66–68, 2006.
Tago E.: COBE kobe Nobel! *Tähetorni Kalender 2007*, 69–71, 2006.
Tenjes P.: Professor Grigori Kuzmini teaduslikust pärandist. *Tähetorni Kalender 2007*, 53–55, 2006.
Tuvikene T.: Mis asi on planeet? *Tähetorni Kalender 2007*, 61–65, 2006.
Tuvikene T.: Hugo Raudsaar. In Memoriam. *Tähetorni Kalender 2007*, 93–94, 2006.

6.3.2 Atmospheric physics Atmosfäärifüüsika

Eerme K.: Maa atmosfäär ja klimatoloogia. *Teadusmõte Eestis. Täppisteadused*. Koost. I. Koppel ja P. Saari, Eesti Teaduste Akadeemia, Tallinn, 29–33, 2006.

Eerme K.: Charles Villmann (18.03.1923–25.03.1992). *Eesti Geodeetide Ühing 1926–2006*. EGÜ väljaanne, Tartu, 51–52, 2006.

Kallis A.: Aastalõpp hea – kõik hea. *Maaleht*, 05.01.2006.

Kallis A.: Jõulukuu tegi pakase ja lumega talvekuule ära! *Postimees*, 11.01.2006.

Kallis A.: Kelle nägu oli läinud aasta? *Maaleht*, 12.01.2006.

Kallis A.: Kes teeb ilma Torino olümpial? *ilm.ee*, 17.01.2006.

Kallis A.: Kuidas mõõta külmatunnet? *ilm.ee*, 21.01.2006.

Kallis A.: Kas sellised pakased on Eestis haruldased? *ilm.ee*, 27.01.2006.

Kallis A.: Kolm päikest korraga taevas? *ilm.ee*, 27.01.2006.

Kallis A.: Veel windchillist. *ilm.ee*, 31.01.2006.

Kallis A.: Vastuoluline näärikuu. *Maaleht*, 02.02.2006.

Kallis A.: Üle päeva külmapühad – hurraa! *Eesti Päevaleht*, 17.02.2006.

Kallis A.: Näärikuu üllatas järskude ilmakäänakutega. *Postimees*, 14.02.2006.

Kallis A.: Ilm ja rõivas. *Maaleht*, 23.02.2006.

Kallis A.: Igati rahvuslik küünlakuu. *Maaleht*, 09.03.2006.

Kallis A.: Tänavune lumerohke küünlakuu vääris küünlaid. *Postimees*, 22.03.2006.

Kallis A.: Mägedes varitseb valge surm. *Maaleht*, 16.03.2006.

Kallis A.: Suveajale üleminek märtsis suvesooja ei toonud. *Postimees*, 19.04.2006.

Kallis A.: Paastukuu oli talvise moega. *Maaleht*, 06.04.2006.

Kallis A.: Kuhu läheb Eesti lumi? *Maaleht*, 27.04.2006.

Kallis A.: Jürikuu oli keskmisest soojem. *Maaleht*, 04.05.2006.

Kallis A.: Soojataat tõi jürikuu keskel korraliku kevade välja. *Postimees*, 09.05.2006.

Kallis A.: Suitsu ja tolmu mitmel pool. *ilm.ee*, 14.05.2006.

Kallis A.: Ajalehed ähvardavad ilmaga! *Maaleht*, 25.05.2006.

Kallis A.: Kasulik selts välgust rabatuile. *ilm.ee*, 27.05.2006.

Kallis A.: Ilmatüdrukust suurilmadaamiks. *Eesti Päevaleht*, 19.06.2006.

Kallis A.: Maikuine näpistav öökülm jättis õunad ussideta. *Postimees*, 20.06.2006.

Kallis A.: UV-kiirguse tase väga kõrge! *ilm.ee*, 29.06.2006.

Kallis A.: Tuuleskaala suur juubel. *Maaleht*, 29.06.2006.

Kallis A.: Kuum ja kuiv jaanikuu. *Maaleht*, 06.07.2006.

Kallis A.: Jaanikuul avanesid taevaluugid – päikesele ja soojale. *Postimees*, 14.07.2006.

Kallis A.: Kaval värk – niiskus. *Maaleht*, 20.07.2006.

Kallis A.: Juuli oli jaanist kuumem. *Maaleht*, 03.08.2006.

Kallis A.: Uuest ilmarekordist. *ilm.ee*, 08.08.2006.

Kallis A.: Juulikuu tõi ka Eestisse troopikakuumuse. *Postimees*, 10.08.2006.

Kallis A.: Ära usu iga ilmauudist! *Maaleht*, 24.08.2006.

Kallis A.: Sängu, Pärna Priit! *Eesti Päevaleht*, 21.08.2006.

Kallis A.: August kustutas janu. *Maaleht*, 07.09.2006.

Kallis A.: Augusti tavapärased ootamatused päädisid tormiga. *Postimees*, 15.09.2006.

Kallis A.: NASA kardab välku. *Maaleht*, 21.09.2006.

Kallis A.: Kliima mõjureist puudub selge arusaam. *Eesti Päevaleht*, 04.10.2006.

Kallis A.: Suvine seenerikas september. *Maaleht*, 05.10.2006.

Kallis A.: Septembrikuu kinkis helde vananaistesuve. *Postimees*, 13.10.2006.

Kallis A.: Ilm on Briti monarhia poolt. *Maaleht*, 19.10.2006.

Kallis A.: Vembukas vesine viinakuu. *Maaleht*, 02.11.2006.

Kallis A.: Vihmane soe viinakuu lõppes tormiliselt. *Postimees*, 16.11.2006.

Kallis A.: Võrumaa on tuultele valla. *Võrumaa Teataja*, 23.11.2006.

Kallis A.: Kes pelgab ilma? *Maaleht*, 23.11.2006.

Kallis A.: Ilm. Ülevaade ilmaoludest september 2005–september 2006. *Aastaraamat Kes? Mis? Kus? 2007*. Tänapäev, 415–428, 2006.

Kallis A.: Ilmataat läks omadega puhta sassi! *Maaleht*, 14.12.2006.

Kallis A.: Talvekuu ilmad meenutasid pigem jürikuud. *Postimees*, 19.12.2006.

Kallis A.: Kas Jõululaps tembutab jälle? *Maaleht*, 21.12.2006.

Kuusk A.: Satelliidid jälgivad Maad. *Teadusmõte Eestis. Täppisteadused*. Koost. I. Koppel ja P. Saari, Eesti Teaduste Akadeemia, Tallinn, 35–38, 2006.

Veismann U.: Nõukogude Liidu aatomipommi saamisloost. *Akadeemia 2*, 287–336, 2006.

Veismann U.: Aastakümned Eesti aime(kirjanduse) maastikul. *Horisont 6*, 10–13, 2006.

6.4 Grant Reports Grandiaruanded

Kipper T.: Evolution of Luminous Non-Stable Stars. *Grant of the Estonian Science Foundation No 5003, Final Report.* 17 pp, 2006.

Kärner O.: Modelling the Global Temperature Series. *Grant of the Estonian Science Foundation No 5004, Final Report.* 11 pp, 2006.

Nugis T.: Stellar Evolution at Low Metallicity: Mass Loss, Explosions, Cosmology. *Grant of the Estonian Science Foundation No 6102, Final Report.* 17 pp, 2006.

6.5 Preprints Preprindid

Burmeister M., Leedjärv L.: Evidence for Bipolar Jets from the Optical Spectra of the Prototypical Symbiotic Star Z Andromedae [astro-ph/0611475].

Einasto J.: Formation of the Supercluster-Void Network [astro-ph/0609686].

Einasto J., Einasto M., Tago E., Suhhonenko I., Jaaniste J., Heinämäki P., Müller V., Knebe A., Tucker D.: Superclusters of Galaxies from the 2dF Redshift Survey. I. The Catalogue [astro-ph/0603764].

Einasto J., Einasto M., Tago E., Saar E., Hütsi G., Jõeveer M., Liivamägi L.J., Suhhonenko I., Jaaniste J., Heinämäki P., Müller V., Knebe A., Tucker D.: Superclusters of Galaxies from the 2dF Redshift Survey. II. Comparison with Simulations [astro-ph/0604539].

Einasto M., Einasto J., Tago E., Saar E., Liivamägi L.J., Jõeveer M., Hütsi G., Heinämäki P., Müller V., Tucker D.: Superclusters of Galaxies from the 2dF Redshift Survey. III. The Properties of Galaxies in Superclusters [astro-ph/0609749].

Haud U., Kalberla P.M.W.: Gaussian Decomposition of H I Surveys – III. Local H I. [http://www.aai.ee/∼ urmas/ast/Local.pdf]

Nurmi P., Heinämäki P., *Saar E., Einasto M.,* Holopainen J., Martínez V. J., *Einasto J.*: Subhaloes in ΛCDM Cosmological Simulations. I. Masses and Abundances [astro-ph/0611941].

Saar E., Martínez V. J., Starck J.-L., Donoho D. L.: Multiscale Morphology of the Galaxy Distribution [astro-ph/0610958].

Saar E.: Multiscale Methods [astro-ph/0612370].

Shchekinov Yu.A., *Vasiliev E.*: Particle Decay in the Early Universe: Predictions for 21 cm [astro-ph/0604231].

Vasiliev E., Shchekinov Yu.A.: Primordial Gas Cooling Behind Shockwaves [astro-ph/0604403].

7 Meetings Konverentsid ja seminarid

7.1 Astronomy Astronoomia

Astronomical Seminar (US Naval Observatory, Washington, USA, 14.02.2006) – I. Pustylnik.

Pustylnik I.: On The Influence of Mass Loss and Angular Momentum Loss on the Evolution in Binary Systems With Hot Subdwarfs (EHB objects) (oral presentation).

Seminar dedicated to E.J. Öpik (National Air and Space Museum, Washington, USA, 22.02.2006) – I. Pustylnik.

Pustylnik I.: Collecting Materials in Archives and Libraries in Washington DC for Scientific Biography of Ernst Julius Öpik (1893–1985) (oral presentation).

Hungarian Academy of Sciences Conference "Detre 100" (Budapest, Hungary, 20.04.2006) – J. Einasto.

Einasto J.: Formation of the Superclusters-Void Network (oral presentation).

Uppsala University Astronomical Seminar (Uppsala University, Sweden, 27.04.2006) – J. Einasto.

Einasto J.: Superclusters of Galaxies (oral presentation).

Uppsala University Physics Colloquium (Uppsala University, Sweden, 28.04.2006) – J. Einasto.

Einasto J.: Dark Matter Story (oral presentation).

Board of Directors Meeting, "Astronomy and Astrophysics" (Dwingeloo, The Netherlands, 06.05.2006) – L. Leedjärv.

Workshop "The Nature of V838 Mon and Its Light Echo" (La Palma, Spain, 15.05.–19.05.2006) – T. Kipper, I. Kolka, T. Liimets.

Kipper T.: Chemical Composition of V838 Mon (oral presentation).

Kolka I.: Spectral Variability and Binary Nature of V838 Mon (oral presentation).

Liimets T.: The Light Echo of V838 Mon (oral presentation).

Regional Astronomical Conference "Close Binary Stars in Modern Astrophysics" (Moscow, Russia, 21.05.–28.05.2006) – I. Pustylnik.

Pustylnik I., Pustynski V.-V.: On the Influence of Mass Loss and Angular Momentum Loss on the Evolution of Binaries with Hot Subdwarfs (oral presentation).

Pustylnik I., Kalv P., Harvig V.: RX Cas Revisited (poster).

Conference "Parenago 100" (Moscow, Russia, 25.05.2006) – J. Einasto.

Einasto J.: From Galactic Models to Dark Matter (oral presentation).

Workshop on Mass Loss from Stars and the Evolution of Stellar Clusters (Lunteren, The Netherlands, 29.05.–01.06.2006) – T. Nugis.
Nugis T.: Optically Thick Winds of Hot Stars: What Determines the Mass Flux? (poster).

Aspen Workshop "Cosmic Voids" (Aspen, USA, 30.05.–27.06.2006) – J. Einasto.
Einasto J.: Voids in Galaxy Distribution (oral presentation).
Einasto J.: 2dF and SDSS Supercluster Network (oral presentation).
Einasto J.: Evolution of the Supercluster-Void Network (oral presentation).
Einasto J.: Supercluster Evolution (oral presentation).
Einasto J.: Supercluster-Void Network (oral presentation).

Seminar on ASTRONET and Nordic Optical Telescope (Vilnius, Lithuania, 05.06.–06.06.2006) – I. Kolka, L. Leedjärv, A. Tamm.
Leedjärv L.: Astronomy in the System of R&D in Estonia (oral presentation).

OPTICON FP7 Planning Meeting (Edinburgh, UK, 22.06.–23.06.2006) – L. Leedjärv.

Challenges of Relativistic Jets (Cracow, Poland, 25.06.–01.07.2006) – I. Vurm.

Cosmic Stories: Bernard's Journey Across the Universe (Valéncia, Spain, 26.06.–30.06.2006) – J. Einasto, E. Saar.
Einasto J.: Supercluster-Void Network (oral presentation).

Conference "Astronomy-2006" (Saint-Petersburg, Russia, 26.06.–29.06.2006) – E. Vasiliev.
Vasiliev E.: Decaying Dark Matter Particles and Observations of the Early Universe in the 21-cm Line (poster).

Conference "Chemodynamics-2006" (Lyon, France, 09.07.–14.07.2006) – E. Vasiliev.
Vasiliev E.: Critical Metallicity for Post-Pop III Stars (poster).

Euroscience Open Forum – ESOF2006 (Munich, Germany, 14.07.–19.07.2006) – I. Pustylnik.

Summer School "Supercomputational Cosmology" (Potsdam Astrophysical Institute, Potsdam, Germany, 17.07.–11.08.2006) – L. J. Liivamägi.

Cosmic Frontiers (Durham, UK, 31.07.–04.08.2006) – A. Tamm, E. Tempel.
Tamm A.: Observing the Evolution of Disk Galaxies (poster).

15th European White Dwarfs Workshop (Leicester University, UK, 07.08.–11.08.2006) – V.-V. Pustynski.
Pustynski V.-V., Pustylnik I.: About the Evolutionary History of the Progenitors of EHBs and Related Binary Systems (poster).

26th General Assembly of the International Astronomical Union (Prague, Czech Republic, 14.08.–25.08.2006) – T. Eenmäe, L. Leedjärv, I. Pustylnik, E. Vasiliev.
Gális R., Hric L., *Leedjärv L.*, Šuhada R.: Long-Term Photometric Behaviour of the Symbiotic System AG Dra (poster).

Pustylnik I., Kalv P., *Harvig V.*, Aas T., *Mars M.*: UU Cnc and BM Cas – Two Long-Period Eclipsing Binaries Involving Supergiant Primaries: Intrinsic Variability as a Circumstantial Evidence on Ongoing Common Envelope Activity (oral presentation).

Pustylnik I., Pustynski V.-V.: What Can We Learn about the Evolutionary History of Progenitors of EHBs and Related Binary Systems from their Observed Properties? (poster).

Pustylnik I.: Ernst Öpik's Scientific Legacy and Its Impact on Modern Astrophysics (poster).

Korpi M. J., *Pelt J.*, Brooke J. M., Tuominen I.: On the Nonaxisymmetricity of the Sunspot Distribution: Kinematic Frame Constructions and their Implications, Solar and Stellar Activity Cycles (poster).

Joint Discussion 7, the XXVIth IAU General Assembly (Prague, Czech Republic, 17.08.–18.08.2006) – E. Vasiliev.

Vasiliev E.: Additional Sources of Ionization in the Early Universe and the 21-cm Line (oral presentation).

Workshop "Evolution and Chemistry of Symbiotic Stars, Binary post-AGB and Related Objects" (Wierzba, Poland, 28.08.–30.08.2006) – M. Burmeister, L. Leedjärv.

Leedjärv L., Burmeister M.: The Peculiar Star CH Cygni on the Background of Heterogeneity of Symbiotic Stars (oral presentation).

Memorial Scientific Session Dedicated to E.J. Öpik (Tallinn, Estonia, 31.08.2006) – J. Pelt, I. Pustylnik, M. Ruusalepp.

Pustylnik I.: Ernst Julius Öpik (1893–1985) – Scientist and Personality (oral presentation).

Precision Spectroscopy in Astrophysics (Aveiro, Portugal, 11.09.–15.09.2006) – A. Aret.

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

Spectroscopic Methods in Modern Astrophysics (INASAN, Moscow, Russia, 13.09.–15.09.2006) – A. Sapar, L. Sapar.

Sapar A., Poolamäe R., Sapar L., Aret A.: Computation of Model Atmospheres and Spectra of Hot Stars by Program SMART: Results and Problems (oral presentation).

Sapar A., Aret A., Sapar L., Poolamäe R.: Isotope Segregation in the Atmospheres of CP Stars due to LID (oral presentation).

ADASS XVI (Tucson, Arizona, USA, 15.10.–19.10.2006) – K. Annuk.

Annuk K.: Astronomical Archive at Tartu Observatory (poster).

Astronomical Seminar (Astronomical Institute of the Slovak Academy of Sciences, Tatranská Lomnica, Slovakia, 23.11.2006) – I. Pustylnik.

Pustylnik I.: Extreme Horisontal Branch (EHB) Objects in Binary Systems (lecture).

Towards the European Extremely Large Telescope (Marseilles, France, 27.11.–01.12.2006) – K. Annuk.

International Astronomical Seminar for Observers of Variable Stars "Kolos 2006" (Humenne, Slovakia, 30.11.–02.12.2006) – I. Pustylnik.

Pustylnik I.: sse.f – a Useful Educational Tool for Astronomical Seminars on Stellar Evolution (lecture).

Groningen University Seminar (Kapteyn Institute, The Netherlands, 08.12.2006) – J. Einasto.

Einasto J.: Luminosity Function of 2dF Galaxies, Clusters and Superclusters (oral presentation).

Conference "Cosmic Voids – Much Ado About Nothing" (Amsterdam, The Netherlands, 15.12.2006) – J. Einasto.

Einasto J.: Evolution of Galaxies and Clusters in Voids and Superclusters (oral presentation).

IAU Symposium 241 "Stellar Populations as Building Blocks of Galaxies" (La Palma, Spain, 10.12.–16.12.2006) – J. Vennik.

Vennik J., Hopp U.: Stellar Ages and Star-Forming Properties of Galaxies in a Dense Group around IC 65 (poster).

7.2 Atmospheric physics Atmosfäärifüüsika

HYRESSA Kick-off Meeting (Mol, Belgium, 06.02.–07.02.2006) – M. Mõttus.

Workshop "3D Remote Sensing in Forestry" (Vienna, Austria, 14.02.–15.02.2006) – A. Kuusk, M. Mõttus.

Kuusk A.: Radiative Transfer in a Forest (keynote presentation).

Mõttus M., Stenberg P., Rautiainen M.: Calculating Photon Recollision Probability for 3-D Forest Canopies (oral presentation).

Ocean Sciences Meeting (Honolulu, Hawaii, USA, 20.02.–24.02.2006) – A. Reinart.

Reinart A., *Alikas K.*, Kutser T.: Evaluation of the Chlorophyll Concentration Data From MERIS for Optically Complex Coastal and Lake Waters in the Baltic Sea Region (poster).

Second Working Meeting on MERIS and AATSR Calibration and Geophysical Validation (MAVT-2006) (ESA ESRIN, Frascati, Italy, 19.03.–25.03.2006) – A. Reinart.

Reinart A., Teral H., Kratzer S.: Comparison of AERONET Data from Two Stations in the Baltic Sea Region (poster).

4th International Workshop on Multi-Angular Measurements and Models (Sydney, Australia, 20.03.–24.03.2006) – M. Mõttus.

Mõttus M., Stenberg P., Rautiainen M.: Compatibility of Photon Recollision Probability with a Physically-Based Forest Reflectance Model (poster).

The Sixth COST 726 Member Countries Meeting (Larnaca, Cypros, 06.04.–07.04.2006) – K. Eerme.

Baseline Surface Radiation Network Meeting (Lindenberg, Germany, 29.05.–03.06.2006) – U. Veismann, A. Kallis, I. Ansko.

Veismann U., Ansko I., Eerme K., Kallis A., Maasik E.-M.: Solar UV Radiation Measurements in Estonia (poster).

Panel Review Meeting for the WMO/UNEP "Scientific Assessment of Ozone Depletion: 2006" (Les Diablerets, Switzerland, 19.06.–23.06.2006) – K. Eerme.

HYRESSA SWOT & User Needs Workshop (Munich, Germany, 05.07.–06.07.2006) – M. Mõttus.

WMO International Conference "Living with Climate Variability and Change: Understanding the Uncertainties and Managing the Risk" (Espoo, Finland, 17.07.–21.07.2006) – A. Kallis.

Eerme K., Kallis A.: Year-to-Year Variations of Global Solar Radiation at Tartu-Tõravere Meteorological Station, Estonia, in 1953–2005 (poster).

Sixth European Conference on Applied Climatology (ECAC2006) (Ljubljana, Slovenia, 03.09.–07.09.2006) – V. Russak.

Russak V.: Changes in Solar Radiation in Estonia During the Last Half-Century (poster).

European Large Lakes Symposium (Tartu, Estonia, 10.09.–15.09.2006) – A. Reinart, K. Alikas, K. Valdmets.

Reinart A., Reinhold M., Kärbla M.: MODIS-Derived Water Temperatures over Large European Lakes (oral presentation).

Alikas K., Reinart A.: Validation of MERIS Products Over Large European Lakes – Peipsi, Vänern and Vättern (poster).

Valdmets K., Reinart A.: Remote Sensing Reflectance Spectra in Accordance of Optical Water Type (poster).

The Seventh COST 726 Member Countries Meeting (Stockholm, Sweden, 11.09.–12.09.2006) – K. Eerme.

SPIE Conference "Europe Remote Sensing of Clouds and the Atmosphere" (Stockholm, Sweden, 11.09.–14.09.2006) – K. Eerme, S. Lätt.

Eerme K., Veismann U., Ansko I., Lätt S.: Year-to-Year Variations of the Vitamin D Synthesis Related UV-B Radiation in Estonia in Autumn and Spring (oral presentation).

Koepke P., DeBacker H., Bais A. F., Curylo A., *Eerme K.*, Feister U., Johnsen B., Junk J., Kazantzidis A., Krzyscin J., Lindfors A., Olseth J. A., den Outer P., Pribullova A., Schmalwieser W. A., Slaper H., Staiger H., Verdebout J., Vuillemier L., Weihs P.: Modeling Solar UV Radiation in the Past: Comparison of Algorithms and Input Data (oral presentation).

4th CHRIS Proba Workshop (Esrin, Italy, 19.09.–21.09.2006) – M. Lang.

Lang M.: Angular Dependence of Forest Reflectance Measured From CHRIS Proba Images over Järvselja Testsite, Estonia (oral presentation).

2nd International Symposium "Recent Advances in Qualitative Remote Sensing" (Torrent (Valéncia), Spain, 25.09.–29.09.2006) – T. Nilson, M. Mõttus.
Nilson T., Suviste S., *Lükk T.*, Eenmäe A.: Seasonal Reflectance Course of Some Forest Types in Estonia as Determined from a Series of Landsat TM and SPOT Images and Via Simulation (oral presentation).
Mõttus M., Stenberg P., Rautiainen M.: Compatibility of Photon Recollision Probability with a Physically-Based Forest Reflectance Model (poster).

Patterns and Processes in Forest Landscapes. Consequences of Human Management. 4th Meeting of IUFRO Working party 8.10.03 (Locorotondo, Bari, Italy, 26.09.–29.09.2006) – U. Peterson.
Peterson U., Liira J., Budenkova J., Kiviste A.: Forest Cover Changes Since mid-1980s in the Eastern Baltic Region, Evaluated with Multitemporal Landsat Imagery (oral presentation).

Workshop About AERONET Measurements in Sweden and Estonia (Stockholm, Sweden, 27.09.–30.09.2006) – A. Reinart.
Reinart A., *Alikas K.*, Teral H.: Comparison of MERIS Aerosol Products with AERONET Data (poster).

Finnish Remote Sensing Seminar (Kaukokartoituspäivät, Helsinki, Finland, 09.11.–10.11.2006) – M. Mõttus.

Baltic Sea and European Marine Strategy – Linking Science and Policy (Helsinki, Finland, 13.11.–15.11.2006) – A. Reinart.

Modern Problems of Sustainable Forest Management, Inventory and Monitoring of Forests (Saint-Petersburg, Russia, 22.11.–24.11.2006) – U. Peterson.
Peterson U., Liira J., Budenkova J., Kiviste A.: Forest Cover Changes Since mid-1980s in the Eastern Baltic Region, Evaluated with Multitemporal Landsat Imagery (oral presentation).

7.3 Meetings at Tartu Observatory Tartu Observatooriumis korraldatud konverentsid

28. augustil 2006 toimus Tartus Tartu Observatooriumi korraldusel regulaarne üle-Eestiline VIII Keskkonnakaitse alane nõupidamine "Atmosfäär. Inimene. Ultraviolettkiirgus". Osavõtjaid Eesti erinevatest uurimis- ja ametiasutustest oli 20.

On August 28, Tartu Observatory organized in Tartu the Estonian Eighth Environmental Protection Related Workshop: Atmosphere. Human. Ultraviolet Radiation. There were 20 participants from research and governmental institutions. The following oral reports in Estonian were presented:

Veismann U., Kallis A., Maasik E.-M.: UV kiirguse mõõtmise aparatuur Tõraveres ja perspektiivid.

Ansko I., Veismann U.: UV aparatuuri kalibreerimine Tõraveres.

Eerme K.: Erüteemse UV kiirguse klimatoloogia Eesti kohta 1955–2004 ja COST 726 raames koostatav klimatoloogia Euroopa kohta.

Kerner E.-S., *Eerme K.*: Stratosfääri osoonihulga seos tropopausi kõrgusega.

Reinart A., Kikas Ü., Tamm E.: Atmosfääri aerosooli tüübi ja vertikaalsete meteoparameetrite mõju aerosooli optilise tiheduse kujunemisele Tõraveres.

Vaht M.: Ultraviolettkiirgus, kasvajad ja autoimmuunhaigused.

Lätt S., Eerme K., Veismann U., Ansko I.: "Vitamiin D talv" Eestis ja vitamiin D sünteesiva kiirguse doosi määramine.

7.4 Miscellaneous Muud koosolekud ja ettevõtmised

SURE Announcement of Opportunity Seminar (Experiments in the International Space Station) (Tallinn, Estonia, 08.02.2006) – L. Leedjärv, S. Lätt, J. Pelt.
Leedjärv L.: Kosmoseuuringutest Eestis (oral presentation).

Visit of the delegation of Estonia to the European Space Agency Headquarters (Paris, France, 10.03.2006) – L. Leedjärv.

Numerical Weather Prediction Vision Workshop (Reading, UK, 15.03.–17.03.2006) – T. Viik.

EMHI konverents "Loodusõnnetuste tagajärgede ennetamine ja leevendamine" (Tallinn, Estonia, 23.03.2006) – T. Viik.

European High-Level Space Policy Group Expert Meeting (Brussels, Belgium, 07.06.2006) – L. Leedjärv.

2006 EUMETSAT Conference (Helsinki, Finland, 12.06.–16.06.2006) – T. Viik.
Viik T.: F.W. Bessel and Geodesy (oral presentation).

Scientific expedition to the Baltic Sea (10.07.–19.07.2006) – A. Reinart, K. Valdmets.

Struve Geodetic Arc (Haparanda and Pajala, Sweden, 13.08.–15.08.2006) – T. Viik.

Scientific expedition to the Baltic Sea (21.08.–23.08.2006) – K. Alikas, K. Valdmets.

European High-Level Space Policy Group Expert Meeting (Paris, France, 20.09.2006) – L. Leedjärv.

Conference "National Space Law. Development in Europe – Challenges for Small Countries" (Graz, Austria, 21.09.–22.09.2006) – L. Leedjärv.

NATO Advanced Research Workshop "Recent Global Catastrophes and their Impact on Human Awareness and Behavior" (Tallinn, Estonia, 26.10.–28.10.2006) – I. Pustylnik.
Pustylnik I., Seltz R.: Mission of Euroscience and its Regional Sections in Managing Crises (oral presentation).

Nordic Network to Improve Methods for Aquatic Environmental Monitoring. Organizing Committee Meeting (Oslo, Norway, 30.10.–04.11.2006) – A. Reinart.

EURISY Programmatic Steering Committee Meeting (Paris, France, 08.11.2006) – L. Leedjärv.

European High-Level Space Policy Group Expert Meeting (Paris, France, 09.11.2006) – L. Leedjärv.

Engineering and Physical Sciences Research Council Annual Meeting (London, UK, 02.11.2006) – T. Viik.

European High-Level Space Policy Group Meeting (Brussels, Belgium, 22.11.2006) – L. Leedjärv.

European High-Level Space Policy Group Meeting (Paris, France, 14.12.2006) – L. Leedjärv.

A. Kallis was an editor of the *Handbook of Estonian Snow Cover*. Koostajad: H. Tooming, J. Kadaja. Toimetaja: A. Kallis. EMHI, EMI.Tallinn-Saku. 504 pp., 2006.

Editing of two papers on astrophysics submitted for publication in "Central Europe Journal of Physics" – I. Pustylnik.

The Chairman of the LOC of NATO Advanced Research Workshop "Recent Global Catastrophes and their Impact on Human Awareness and Behavior" – I. Pustylnik.

Secretary of the Organizing Committee of the European Large Lakes Symposium (September 10–15, 2006, Tartu, Estonia) – A. Reinart.

T. Viik consulted translating several books into Estonian:

M.K. Baumann, W. Hopkins, M. Soluri, L. Nolletti: Mis on maailmaruumis, Sinisukk, 2005.

B. Bryson: Kõiksuse lühiajalugu, Pegasus, 2006.

Kiirgus, inimesed ja keskkond, IAEA, 2006.

8 Visits and guests Visiidid ja külalised

8.1 Astronomy Astronoomia

V.-V. Pustynski – Queens University, Belfast (Northern Ireland, UK); 08.01.–20.01.2006.

I. Vurm – Oulu University, Oulu (Finland); 12.02.–28.02.2006.

K. Annuk – Astronomical Institute, Utrecht University (The Netherlands); 19.02.–26.02.2006.

T. Nugis – Astronomical Institute, Utrecht University (The Netherlands); 19.02.–26.02.2006.

J. Pelt – Helsinki University, Helsinki (Finland); 12.03.–18.03.2006.

V. Malyuto – Lohrmann Observatory, Dresden University of Technology, Dresden (Germany); 13.03.–19.03.2006.

V. Malyuto – Observatoire de Bordeaux, Bordeaux (France); 02.04.–07.04.2006

L. Leedjärv – Astronomical Institute, Utrecht University (The Netherlands); 07.05.–09.05.2006.

E. Vasiliev – Rostov State University, Rostov-on-Don (Russia); 16.07.–12.08.2006.

I. Vurm – Oulu University, Oulu (Finland); 18.08.–31.08.2006.

A. Tamm – Institute for Astrophysics, University of Göttingen (Germany); 01.10.–29.10.2006.

E. Saar – Observatori Astronomic, Universitat de Valéncia, Valéncia (Spain); 11.10.–07.12.2006.

M. Gramann – University College London, London (UK); 18.10.–25.10.2006.

J. Einasto – Astrophysical Institute Potsdam (Germany); 14.10.–17.12.2006.

I. Vurm – Oulu University, Oulu (Finland); 01.11.–18.11.2006.

I. Pustylnik – Astronomical Institute of the Slovak Academy of Sciences, Tatranská Lomnica (Slovakia); 10.11.–03.12.2006.

V. Malyuto – Lohrmann Observatory, Dresden University of Technology, Dresden (Germany); 04.12.–22.12.2006.

I. Pustylnik – Sternberg Astronomical Institute (Moscow, Russia); 10.12.–14.12.2006.

8.2 Atmospheric physics Atmosfäärifüüsika

A. Reinart – Stockholm University (Sweden); 06.03.–10.03.2006.

K. Valdmets – Field Campaign in North Sea and Waddenzee, Amsterdam Vrije Universiteit (The Netherlands); 30.04.–16.05.2006.

A. Kallis – Institute for Atmospheric and Climate Science, ETH Zürich (Switzerland); 08.05.–28.05.2006.

A. Kallis – Physikalisch-Meteorologisches Observatorium Davos / World Radiation Center, Davos (Switzerland); 26.05.2006.

A. Kallis, U. Veismann, I. Ansko – Lindenberg Physikalisches- Meteorologisches Observatorium (Lindenberg, Germany); 29.05.–03.06.2006.

S. Lätt – Swedish National Testing and Research Institute (Borås, Sweden); 14.09.–15.09.2006.

A. Reinart – EC Joint Research Centre, Institute for Environment and Sustainability (Ispra, Italy); 16.09.–23.09.2006.

K. Alikas – ESA Training Course at the Institute of Oceanography of the University of Hamburg (Germany); 25.09.–29.09.2006.

A. Reinart – Helsinki Technical University, Institute of Meteorology, TEKES (Helsinki, Finland); 12.11.–17.11.2006.

M. Mõttus – Instituto Nacional de Tecnica Aeroespacial (Madrid, Spain); 19.11.–23.11.2006.

S. Lätt – Helsinki University of Technology, Metrology Research Institute and STUK (Helsinki, Finland); 27.11.–02.12.2006.

A. Kallis – Finnish Environment Institute (Finland); 08.12.–09.12.2006.

U. Veismann – Physikalisch-Technische Bundesanstalt, Berlin and Braunschweig (Germany); 04.12.–11.12.2006.

8.3 Guests of the observatory Observatooriumi külalised

Dale Kiefer – Department of Biological Sciences, University of Southern California (USA); 14.01.–29.01.2006.

Pasi Nurmi – Tuorla Observatory, University of Turku (Finland); 08.02.–10.02.2006, 04.10.–06.10.2006.

Pekka Heinämäki – Tuorla Observatory, University of Turku (Finland); 08.02.–10.02.2006, 04.10.–06.10.2006.

Nils Bergvall – Uppsala University (Sweden); 20.04.–21.04.2006.

9 Seminars at the Observatory Observatooriumis toimunud seminarid

9.1 Astronomy Astronoomia

11.01.2006 – Jaan Vennik: Galaktikarühmade alasest konverentsist Santiagos.
18.01.2006 – Tõnis Eenmäe, Hardi Teder: Arvutamine – see on imelihtne!
25.01.2006 – Maret Einasto: GOODS'i uudised.
15.02.2006 – Tõnu Viik: Tycho Brahe – kuulus taanlane.
22.02.2006 – Indrek Kolka: Muutlik täht V838 Mon.
08.03.2006 – Jaan Einasto: Superparved 2dF väljas.
15.03.2006 – Izold Pustylnik: Uut E. J. Öpiku teaduslikust tööst ja loengutest Marylandi Ülikoolis (1957–1974) (Marylandi Ülikooli, Ameerika Füüsika Instituudi ning Rahvusliku Lennunduse ja Kosmonautika Muuseumi arhiiviandmete põhjal).
05.04.2006 – Jaan Pelt: W. Andersoni tagasitulek (sissejuhatus).
12.04.2006 – Taavi Tuvikene: Vaatlejana lõunapoolkeral.
21.04.2006 – Nils Bergvall (Uppsala University): Recent Studies of Blue Compact Galaxies – Red Halos and Lyman Continuum Leakage.
26.04.2006 – Evgenii Vasiliev: Primordial Gas Cooling Behind Shock Waves in Merging Halos.
03.05.2006 – Anti Hirv: Kuidas Türgis päikesevarjutust vaatamas käidi.
10.05.2006 – Jaan Einasto: Uusimat superparvedest.
24.05.2006 – Jaan Pelt: Astronoomiast Soomes.
31.05.2006 – Tõnu Kipper, Indrek Kolka, Tiina Liimets: Mida nägime ja kuulsime Kanaaridel toimunud V838 Mon-le pühendatud konverentsil.
07.06.2006 – Izold Pustylnik: Prof. Martõnovi mälestuskonverents Moskvas.
13.09.2006 – Laurits Leedjärv, Izold Pustylnik: Muljeid Prahas toimunud IAU Peaassambleelt.
20.09.2006 – Antti Tamm, Elmo Tempel: Kosmilised piirid – konverentsimuljeid Durhamist.
27.09.2006 – Izold Pustylnik, Tõnis Eenmäe: Jätkame teemal "Muljeid Prahas toimunud IAU Peaassambleelt".
04.10.2006 – Lilli Sapar, Arved Sapar: Üldpilt konverentsist "Spektroskoopia meetodid nüüdisastrofüüsikas", Moskva, 13.10.–15.10.2006.
11.10.2006 – Arved Sapar: Moskva konverentsi ettekannete presentatsioon "Programmiga SMART saadud tulemustest".
18.10.2006 – Anna Aret: Uus meetod täheatmosfääride keemilise koostise määramiseks.
25.10.2006 – Anna Aret: Konverents Aveiros, Portugalis.

01.11.2006 – Tõnu Kipper: R CrB tüüpi tähtedest.
08.11.2006 – Erik Tago: COBE Nobel.
06.12.2006 – Kalju Annuk: ADASS XVI ja külaskäigust Kitt Peak'i observatooriumisse.
13.12.2006 – Tõnu Viik: Bessel ja geodeesia.

9.2 Atmospheric physics Atmosfäärifüüsika

20.01.2006 – Dale Kiefer (California): Application of an Oceanographic Information System.
10.02.2006 – Ave Kodar, Krista Alikas, Kristi Valdmets, Eva-Stina Kerner: Kaugseire tudengite ettekanded.
17.03.2006 – Silver Lätt: Ultraviolettkiirguse mõõtmismeetodid ja -vahendid.
21.04.2006 – Joel Kuusk: Metsa heleduse mõõtmine.
05.05.2006 – Ilmar Ansko: Radiomeetriaskaala, etalonkiirgurid ja kalibreerimised TO optilise radiomeetria laboris.
12.05.2006 – Andres Kuusk: PROBA/CHRIS piltide atmosfäärikorrektsioon.
19.05.2006 – Oleg Okulov: Atmosfääri läbipaistvus, veeauru sisaldus ja aerosooli optiline paksus Rootsis ja Eestis aastatel 2002–2003.
02.06.2006 – Madis Sulev: Spektraalmõõtmistest energivõsas.
– Margus Aru, Veiko Laas: Tõravere lepaistanduse biomassi produktsiooni hindamine.
09.06.2006 – Lennart Neimann (Tartu Ülikool): Atmosfääri läbipaistvus Tartus 1931–1940.
– Triin Kutsar: Taandatud suhte indeksi kasutamine metsanduslike muutujate hindamiseks satelliidipiltidelt.
– Roman Belov: Erinevate metsatüüpide kiirgustemperatuurid Landsat 7 satelliidipiltidelt Järvselja näitel.
06.10.2006 – Mart Noorma (Tartu Ülikool): Optiline radiomeetria Helsinki Tehnikaülikoolis ja NIST-is (USA).
13.10.2006 – Kalju Eerme: Ultraviolett B kiirgus ja vitamiin D süntees.
20.10.2006 – Hanno Ohvril (Tartu Ülikool): Õhusamba aerosooli optilistest omadustest Tõraveres 2002–2004. a. AERONET mõõtmistest.
27.10.2006 – Tiit Nilson: PROSPECT leheoptika mudeli laiendamine soojuskiirguse piirkonda.
24.11.2006 – Mait Lang: Lehestiku massi ning võra raadiuse mudelite sobivusest metsa heleduse mudeli sisendandmete koostamisel.
08.12.2006 – Olavi Kärner: Lühiülevaade AERONETi jaamade asutamisest ja kasutamisest A. Smirnovi ettekande alusel.
15.12.2006 – Joel Kuusk: 2006. a. suvel toimunud Järvselja metsade spektraalse heleduse mõõtmise tulemused.
22.12.2006 – Ilmar Ansko: Veealuste spektromeetrite RAMSES kalibreerimisest ja kasutamisest.

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 – A. Reinart
American Optical Society – T. Viik
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
Eco-Ethics International Union – A. Kallis
Editorial Board "Agricultural and Forest Meteorology" – A. Kuusk
Editorial Board "Astronomical and Astrophysical Transactions" – I. Pustylnik
Editorial Board "Baltic Astronomy" – T. Kipper
Editorial Board "Central European Journal of Physics" – I. Pustylnik
Editorial Board "Journal of Quantitative Spectroscopy and Radiative Transfer" – T. Viik
Editorial Board "Silva Fennica" – T. Nilson
Eesti Astronoomia Selts – K. Annuk, J. Einasto, V. Harvig, T. Kipper, I. Kolka, L. Leedjärv, T. Nugis, J. Pelt, A. Puss, I. Pustylnik, V.-V. Pustynski, M. Ruusalepp, L. Sapar, E. Tago, U. Veismann, T. Viik
Eesti Füüsika Selts – A. Aret, K. Eerme, J. Einasto, T. Kipper, L. Leedjärv, E. Saar, M. Sulev, P. Tenjes, T. Viik
Eesti Geograafia Selts – A. Kallis
Eesti Kosmosepoliitika Töögrupp / Estonian Space Policy Working Group – L. Leedjärv (Vice-Chair), T. Viik
Eesti Kvaliteediühing – U. Veismann
Eesti Kirjanduse Selts – U. Veismann
Eesti Looduskaitse Selts – M. Sulev
Eesti Looduseuurijate Selts – K. Eerme, A. Kallis, V. Russak, A. Sapar, M. Sulev, U. Veismann, T. Viik
Eesti Teadlaste Liit – J. Einasto, T. Viik
Eesti Teaduste Akadeemia / Estonian Academy of Sciences – J. Einasto, A. Sapar
Eesti Rahvuslik Astronoomia Komitee / Estonian National Committee on Astronomy – J. Einasto, L. Leedjärv (Chair), E. Saar, T. Viik
Eesti Geofüüsika Komitee / Estonian Geophysical Committee – K. Eerme
Eesti Teadusfondi nõukogu – T. Viik (alates 01.09.2006)
EURISY Programmatic Steering Committee – L. Leedjärv

European Astronomical Society – K. Annuk, J. Einasto, M. Gramann, V. Harvig, T. Kipper, I. Kolka, L. Leedjärv, V. Malyuto, T. Nugis, I. Pustylnik, V.-V. Pustynski, E. Saar, A. Sapar, L. Sapar, E. Tago, P. Tenjes, U. Veismann, J. Vennik, T. Viik

European High Level Space Policy Group – L. Leedjärv

Eurosciene – I. Pustylnik, U. Veismann

Euro–Asian Astronomical Society – A. Aret, J. Einasto, V. Malyuto, I. Pustylnik, V.-V. Pustynski, A. Sapar

Field Editor "Agronomie. Agriculture and Environment" – A. Kuusk

GAIA Classification Working Group – V. Malyuto

GAIA Photometry Working Group – I. Kolka

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

German Astronomical Society – J. Einasto

International Astronomical Union – K. Annuk, J. Einasto, M. Einasto, M. Gramann, U. Haud, T. Kipper, I. Kolka, L. Leedjärv, V. Malyuto, T. Nugis, J. Pelt, I. Pustylnik, E. Saar, A. Sapar, L. Sapar, I. Suhhonenko, E. Tago, P. Tenjes, U. Veismann, J. Vennik, T. Viik

Marie Curie Fellowship Association – A. Reinart

MTÜ Euroscience Eesti – I. Pustylnik, V.-V. Pustynski

Royal Astronomical Society – J. Einasto (associated member)

Society for European Astronomy in Culture – I. Pustylnik

Teaduskompetentsi Nõukogu / Estonian Council of Scientific Competence – T. Viik (Vice-Chair, kuni 01.09.2006)

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

Õpetatud Eesti Selts – U. Peterson

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 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. Tago, T. Viik.

The Physics of Stars Tähtede füüsika – T. Viik, Tartu University. *[http://www.aai.ee/∼viik/loengukursus "Tähtede füüsika", IV+274 lk.]*

Physical Cosmology Füüsikaline kosmoloogia – E. Tago and M. Gramann, Tartu University.

Astronomy Astronoomia – P. Tenjes, Tartu University.

Master Seminar in Astrophysics Astrofüüsika magistriseminar – P. Tenjes, A. Hirv, Tartu University.

Atomic and Subatomic Physics I Mikromaailma füüsika I – P. Tenjes, Tartu University.

Mathematical Physics I Matemaatiline füüsika I – P. Tenjes, Tartu University.

Methods of Mathematical Physics Matemaatilise füüsika meetodid – P. Tenjes, Tartu University.

11.1.2 Atmospheric physics Atmosfäärifüüsika

Environmental Science Keskkonnaõpetus – K. Eerme, Tartu University.

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

Physical Geography Füüsiline geograafia – A. Kallis, Estonian Maritime Academy.

Applied Meteorology Rakendusmeteoroloogia – A. Kallis, Public Service Academy of Estonia.

Meteorological Technology and Observational Networks Meteotehnoloogia ja vaatlusvõrgud – A. Kallis, Tartu University.

Environmental Remote Sensing Keskkonna kaugseire – T. Nilson, Tartu University.

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

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

Environmental Monitoring and Environmental Protection Keskkonnaseire ja Keskkonnakaitse — U. Peterson, Estonian University of Life Sciences.

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

Computer-Aided Measurements Arvutijuhitavad mõõtmised – U. Veismann together with A. Mirme, Tartu University.

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

Project in Mechatronic Systems Mehatroonikasüsteemide projekt – J. Kuusk (praktikumi juhendaja), Tartu University.

11.2 Popular lectures Populaarteaduslikud loengud ja esinemised

13 intervjuud BNS-ile, raadiole ja televisioonile – T. Viik.

23 intervjuud BNSile, raadiole ja televisioonile – A. Kallis.

Loengusari Raadio2-le aastaaegade ilmast – A. Kallis.

Astronoomia areng Eestis (Seminar "Valdur Tiit 75", Tartu, 15.01.2006) – J. Einasto.

Struve meridiaanikaar UNESCO maailmapärandi nimekirjas (Tartu Hansa Rotary Klubi, 16.01.2006) – T. Viik.

EAS–ESA–SURE seminar (Päevasüda, Vikerraadio, 08.02.2006) – L. Leedjärv.

Thomas Clausen – karjapoisist professoriks (Tartu Ülikooli Ajaloomuuseumi teadusajaloo päev, Tartu, 08.02.2006) – T. Viik.

Struve meridiaanikaar UNESCO maailmapärandi nimekirjas (Eesti Astronoomia Seltsi aastakoosolek, Tallinn, 11.02.2006) – T. Viik.

Eesti ja ESA suhted, kosmoseuuringud Eestis (Keskkonnatelk, Raadio Kuku, 19.02.2006) – L. Leedjärv.

Kõik algab Päikesest (Loodusõhtu Rahvusraamatukogus, raamatu "Universum valguses ja vihmas" tutvustus, Tallinn, 20.03.2006) – L. Leedjärv.

Mis on ilmakatastroof? (Loodusõhtu Rahvusraamatukogus, raamatu "Universum valguses ja vihmas" tutvustus, Tallinn, 20.03.2006) – A. Kallis.

Tähespekter tähefüüsika infoallikana (Eesti füüsikapäevad, Tartu, 22.03.2006) – A. Sapar.

Universum, nagu me teda tunneme (loeng Rakvere Reaalgümnaasiumis, Rakvere, 05.04.2006) – L. Leedjärv.

Pildikesi Universumi ehitusest (loeng AS Kodumajatehas, 11.04.2006) – L. Leedjärv.

Intervjuu Eesti (ja Nõukogude) kosmoseprogrammidest (Eesti Raadio venekeelsed saated, 12.04.2006) – L. Leedjärv.

Loeng "Üks viisidest, kuidas loodus teid tappa püüab – tormid" (Eesti Looduseuurijate Selts, Tartu, 12.04.2006) – A. Kallis.

Eesti teadlased Universumit uurimas (Tartu College, Toronto, Canada, 25.04.2006) – L. Leedjärv.

Kuidas teha galaktikaid? (Tartu Ülikooli astrofüüsika magistriseminar, Tartu, 04.05.2006) – E. Tempel.

Tähtedest astrofüüsiku pilguga: millised nad on, mis neis toimub, kuidas nad arenevad ja milline on tähekiirgus (Rakvere Reaalgümnaasium, 05.05.2006) – A. Sapar.

Konsultatsioonid taevakehade asimuutide määramise alal (J. Vissarionov – EKV Tapa Väljaõppekeskusest, mai-juuni 2006) – J. Vennik.

F.G.W. Struve Maa kuju täpsustajana (Tähise avamine Tartu Tähetorni juures seoses Struve kaare kandmisega maailmapärandi nimekirja, Tartu, 18.06.2006) – T. Viik.

Asteroid 2004 XP14 ja teised ohustajad (Raadio Ring FM, 03.07.2006) – L. Leedjärv.

Ilmanähtustest (Ilmahuviliste päev, Luunja, 13.08.2006) – A. Kallis.

Gammasähvatused ja maailmade saatus (Astronoomiahuviliste XI Üle-Eestiline kokkutulek, Mahtra, 12.08.2006) – E. Tago.

Loeng "Päikese kiirguse mõõtmistest Eestis" (Eesti Maaülikool, 20.09.2006) – A. Kallis.

Maailma ehitus ("Teadlaste öö", Jäneda, 22.09.2006) – J. Einasto.

Kuidas on kujunenud keemilised elemendid, millest koosnevad tähed, Maa ja meie ("Teadlaste öö", Jäneda, 22.09.2006) – A. Sapar.

Maailm ja mõnda (Juristide Liidu seminar, 28.09.2006) – J. Einasto.

Nobeli 2006. a füüsikapreemiast (Vikerraadio saade "Labor", 08.10.2006) – M. Gramann.

Maa ja tema asukad päikesepaistel (Täiskasvanute koolitus, Tartumaa Muuseum, 10.10.2006) – K. Eerme.

Tume aine galaktikates ja nende ümber. (Eesti Füüsika Seltsi Täppisteaduste sügiskool, 21.10.2006) – P. Tenjes.

Tähtede ja planeetide tekkest (Tartu Ülikooli usuteaduskond, loengusari "Algused ja lõpud", 25.10.2006) – L. Leedjärv.

Miks Pluuto enam planeet pole? (Terevisioon, Eesti Televisioon, 27.10.2006) – L. Leedjärv.

Kosmos kui riskiallikas? (Interdistsiplinaarne konverents "Inimteadvus ja käitumine riski tingimustes", Tallinna Ülikool, 27.10.2006) – L. Leedjärv.

Tycho Brahe – kuulus taanlane (Tartu Tähetorni Astronoomiaring, 31.10.2006) – T. Viik.

COBE Nobel (Tartu Tähetorni Astronoomiring, 07.11.2006) – E. Tago.

Nobeli füüsikaauhinnad astronoomidele (Tartu Tähetorni Astronoomiaring, 21.11.2006) – E. Tago.

Loeng "Ilmauudiseid" (Pärnu, Looduskaitse Selts, 25.11.2006) – A. Kallis.

Loengusari "Ilmavaatlustest meil ja mujal" (Tallinn, EMHI, 05.–12.12.2006) – A. Kallis.

Gravitatsiooniläätsed (Tartu Tähetorni Astronoomiaring, 05.12.2006) – E. Tempel.

Rubriik "Ain Kallis ilmast" – veebisaidis *www.ilm.ee*.

11.3 Ph.D. theses defended by the staff of the Observatory Observatooriumi töötajate poolt kaitstud väitekirjad

A. Tamm: Structure of Distant Disk Galaxies. Kaugete ketasgalaktikate strukuur, Ph.D. Thesis, Tartu University.
Defence Kaitsmine: 20.04.2006.
Supervisor Juhendaja: P. Tenjes (Tartu University).
Opponent Oponendid: N. Bergvall (Uppsala), J. Vennik (Tartu Observatory).

G. Hütsi: Cosmic Sound: Measuring the Universe with Baryonic Acoustic Oscillations. Kosmiline heli: Universumi mõõtmine akustiliste barüonvõnkumiste abil. Ph.D. Thesis, Ludwig-Maximilians-Universität München, 2006
Defence Kaitsmine: 30.05.2006.
Supervisor Juhendaja: R. Sunyaev (Max-Planck-Institut für Astrophysik, Garching, Germany).
Opponent Oponent: V. Mukhanov (LMU, München).

M. Lang: The Performance of Foliage Mass and Crown Radius Models in Forming the Input of a Forest Reflectance Model. Lehestiku massi ning võra raadiuse mudelite sobivusest metsa heleduse mudeli sisendandmete koostamisel. Ph.D. Thesis, Estonian University of Life Sciences.
Defence Kaitsmine: 30.11.2006.

Supervisors Juhendajad: T. Nilson (Tartu Observatory), A. Kiviste (Estonian University of Life Sciences.)
Opponent Oponent: J. Varjo (Helsinki University, Finland).

11.4 Supervising of graduation theses Bakalaureusetööde juhendamine

K. Eerme – E.-S. Kerner: Tropopausi temperatuur ja kõrgus ning osoonikihi kogupaksus – seosed Tallinna kohal / Relationships Between the Tropopause Height and Temperature and the Atmospheric Total Ozone Above Tallinn (B.Sc.), Tartu University.

I. Kolka – M. Kama: T Tauri tähtede spektraalsete energiajaotuste põhitüübid, tunnused ja muutlikkus – ettevalmistus Gaia missiooniks / The Spectral Energy Distributions of T Tauri Stars, their Characteristics and Variability – in Preparation for the Gaia Mission (B.Sc.), Tartu University.

T. Nilson – R. Belov: Erinevate metsatüüpide kiirgustemperatuurid Landsat 7 satelliidipiltidelt Järvselja näitel / Radiation Temperatures of Different Forest Types as Measured from Landsat 7 Satellite Images over Järvselja (B.Sc.), Tartu University.

T. Nilson – R. Kutsar: Taandatud suhte indeksi kasutamine metsanduslike muutujate hindamiseks satelliidipiltidelt / Reduced Simple Ratio Index to Estimate Forest Variables from Satellite Images (B.Sc.), Tartu University.

E. Saar – M. Sootla: Galaktikate korrelatsioonifunktsioon suurtel vahekaugustel / Correlation Function of Galaxies at Large Distances (B.Sc.), Tartu University.

U. Veismann – H. Lokk: Päikese ultraviolettkiirguse mõõtesüsteem / Measuring System of Solar Ultraviolet Radiation (B.Sc.), Tartu University.

U. Veismann – T. Tamm: Pilvede määramine taeva kujutises / Detecting of Clouds in Sky Images (B.Sc.), Tartu University.

11.5 Supervising of M.Sc. and Ph.D. theses Magistri- ja doktoritööde juhendamine

P. Tenjes – A. Tamm: Structure of Distant Disk Galaxies (Ph.D.), Tartu University.

T. Nilson – M. Lang: Lehestiku massi ning võra raadiuse mudelite sobivusest metsa heleduse mudeli sisendandmete koostamisel / The Performance of Foliage Mass and Crown Radius Models in

Forming the Input of a Forest Reflectance Model (Ph.D.), Estonian University of Life Sciences.

U. Peterson, J. Liira – K. Püssa: Metsaservad keskmise ruumilise lahutusega Landsat Thematic Mapper satelliidipiltidel / Forest Edges on Medium Resolution Landsat Thematic Mapper Satellite Images (Ph.D.), Tartu University.

U. Peterson – J. Budenkova: Lageraiealade kaardistamine keskmise ruumilise lahutusega talvistelt satelliidipiltidelt / Forest Clear-Cut Mapping with Medium Spatial Resolution Satellite Winter Images (M. Sc.), Estonian University of Life Sciences.

A. Reinart – K. Alikas: MERIS tulemite kontroll Eesti veekogude kaugseire tarbeks / Validation of MERIS Products over Estonian Waters (M.Sc.), Tartu University.

A. Reinart – K. Valdmets: Peipsi järve bio-optiline mudel / Bio-optical Model of Lake Peipsi (M.Sc.), Tartu University.

11.6 Refereeing of theses Oponeerimine

K. Eerme – R. Vabamäe: 2005. aasta jaanuaritormi numbriline modelleerimine ja analüüs / Numerical Modelling and Analysis of the Storm of January 2005 (B.Sc.), Tartu University.

T. Nilson – J. Budenkova: Lageraiealade kaardistamine keskmise ruumilise lahutusega talvistelt satelliidipiltidelt / Forest Clear-Cut Mapping with Medium Spatial Resolution Satellite Winter Images (M. Sc.), Estonian University of Life Sciences.

V. Russak – E.-S. Kerner: Tropopausi temperatuur ja kõrgus ning osoonikihi kogupaksus – seosed Tallinna kohal / Relationships Between the Tropopause Height and Temperature and the Atmospheric Total Ozone Above Tallinn (B.Sc.), Tartu University.

V. Russak – L. Neiman: Atmosfääri läbipaistvus Tartus 1931–1940 / Atmospheric Transparency in Tartu, 1931–1940 (M.Sc.), Tartu University.

J. Kuusk – K. Tamm: Aerosooliosakeste liikuvuse analüsaatori arvutijuhitav pingeallikas / Computer Controlled Voltage Supply for the Aerosol Particle Differential Mobility Analyzer (B.Sc.), Tartu University.

J. Vennik – A. Tamm: Kaugete ketasgalaktikate strukuur / Structure of Distant Disk Galaxies (Ph.D.), Tartu University.

12 Staff Koosseis (01.01.2007)

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From left Vasakult paremale:
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13 Contact data Kontaktandmed

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