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University of Turku

FINCA
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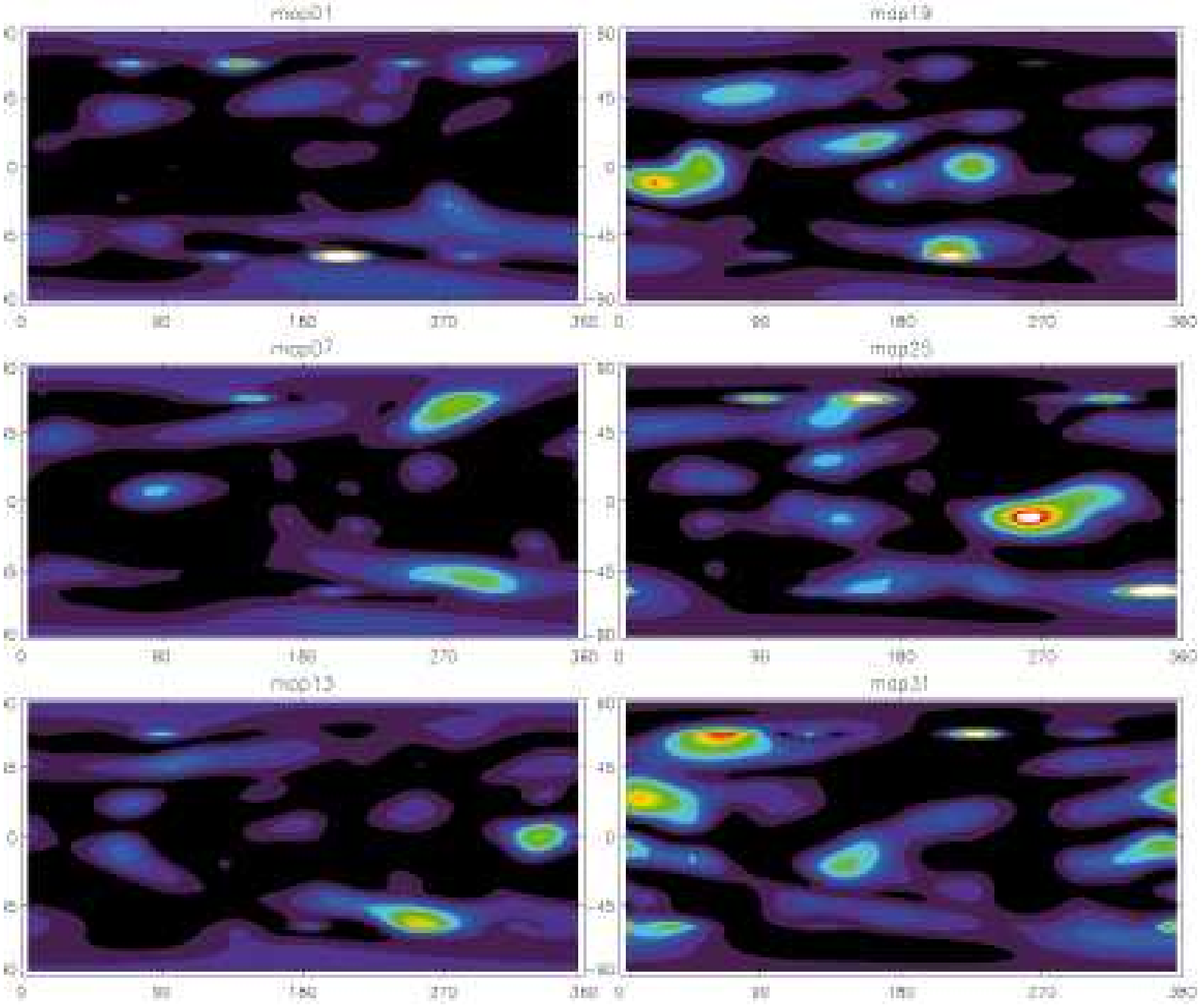
FINNISH CENTRE FOR ASTRONOMY WITH ESO (FINCA)



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Contact information:

Finnish Centre for Astronomy with ESO (FINCA)
University of Turku
Väisäläntie 20
FI-21500 PIIKKIÖ
Finland
Email: finca@utu.fi
WWW: http://finca.utu.fi

Director:
Jari Kotilainen
Tel. +358-2-3338250
Fax: +358-2-3335070
Email: jari.kotilainen@utu.fi

Foreword

Finland became a member of the European Southern Observatory (ESO) in 2004. ESO is a world leading international astronomical research and technology organization, with headquarters in Garching, Germany. ESO operates three world-class observatories in Chile, and it has currently 15 member states.

Efficient and comprehensive utilization of Finland's ESO membership requires coordinated co-operation between all the Finnish universities engaged in astronomical research. The Finnish Centre for Astronomy with ESO (FINCA) is a national research institute for astronomical and astrophysical research in Finland. FINCA coordinates Finnish cooperation with ESO by networking into the ESO infrastructure and projects; practices and promotes high quality research in all fields of astronomy, and ESO-related technological development work; participates in researcher training in astronomy; and fosters and implements ESO-related cooperation of Finnish universities in astronomy. The ultimate goal of FINCA is to improve the scientific and industrial benefit of Finland's membership in ESO, and Finland's international competitiveness in astronomical research.

FINCA started operations 1.1.2010 as a Special Unit of the University of Turku and it is funded by the Ministry of Education and Culture, and by the participating universities (Aalto, Helsinki, Oulu and Turku). The current staff consists of about 20 PhD scientists, majority of them based in the University of Turku.

The highest decision-making body is the Board, comprising of two members from each participating university and one member from the FINCA staff. The chair of the Board is Leo Takalo (University of Turku). A Scientific Advisory Board (SAB) consisting of seven foreign members, oversees the functioning of FINCA. The chairman of the SAB is Prof. Johannes Andersen (University of Copenhagen and NOT).

The research at FINCA covers a large range in contemporary astronomy, from cosmology, distant active galaxies, and galaxy formation and evolution, through studies of the structure of nearby galaxies, to binary stars, stellar magnetic activity, interstellar medium, star formation and exoplanets in our own Galaxy. In our research, we use multi-wavelength observational data from large ground-based and space telescopes, especially from the four 8m class Very Large Telescopes (VLT) and the three 2-4m class telescopes of ESO in Chile, and the Nordic Optical Telescope (NOT) on La Palma, Spain, in the optical, near-infrared and mid-infrared, but also at radio and millimeter wavelengths and at X-ray and gamma-rays. Observational research is supplemented by modelling, simulations and theoretical work, that are essential in the understanding of the physics behind the observational results.

During the next year, the major step forward at ESO, with implications for research at FINCA, will be the completion and start of full science operations of the Atacama Large Millimeter Array (ALMA) in Chile, which already is beginning to revolutionize (sub)millimeter astronomy. On longer term, ESO will soon start to build the European Extremely Large Telescope (E-ELT), a 39 m diameter giant for infrared and optical astronomy, to start operations in about 10 years time. It will never be too early to start adjusting one's research goals for the enormous leap forward in sensitivity and resolution provided by these giants...

Jari Kotilainen
Director of FINCA

FINCA Research Highlights in 2011

Galaxies and Cosmology

Formation of early-type galaxies

Two main formation mechanisms have been proposed to explain the formation of massive early-type galaxies: The binary major merger scenario and the cosmological minor merger scenario. In the binary major merger scenario, elliptical galaxies are formed from the merger of two spiral galaxies and this picture is moderately successful in producing the component of intermediate mass, fast-rotating disky ellipticals with anisotropic velocity distributions. However, the binary merger scenario has problems in reproducing the massive old metal-rich slowly-rotating boxy ellipticals, which are characterized by low ellipticities and more isotropic velocities. The massive slowly rotating ellipticals are better reproduced in simulations set in the cosmological context, in which the galaxy is assembled from multiple, hierarchical mergers of star-bursting subunits.

Peter Johansson and colleagues have studied the cosmological formation of early-type galaxies using high-resolution numerical simulations that include primordial radiative cooling, photo-ionization, star formation, type II supernova feedback, but exclude supernova driven winds and AGN feedback. They found that the simulated galaxies assemble in two phases, with the initial growth dominated by compact in situ star formation fueled by cold, low entropy gas streams, whereas the late growth is dominated by accretion of old stars formed in subunits outside the main galaxy (**Fig 1.**). In this formation picture, the central parts of early type galaxies assemble rapidly at high redshift, whereas the outer parts grow at later times primarily through minor merging. The addition of stellar material in minor mergers also provides a source of gravitational feedback, which strongly suppresses late star formation in massive galaxies contributing to the observed galaxy color bi-modality. In addition, the two-phase formation mechanism naturally explains the observed downsizing of massive early-type galaxies and the size growth of the early-type galaxy population through the combination of early in-situ star formation and late dry stellar accretion.

Polarimetry of optically selected BL Lacertae candidates from the SDSS

BL Lacertae objects (BL Lacs) are a rare class of active galactic nuclei (AGN) with very distinctive properties: rapid variability from radio to gamma-rays, apparent superluminal (faster than light) motion in their cores and high degree of polarization of their radio and optical emission. About 1000 BL Lacs are known today, a small fraction of the total AGN population of ~100,000 AGN.

Although many BL Lacs have been studied in detail and a general picture explaining their properties has been established, many questions related to the BL Lac class remain unclear, like their evolution with cosmic time. This is mainly due to two facts: homogeneously selected, complete BL Lac samples are relatively small in size (typically ~50 targets) and BL Lacs have often been found in single frequency (radio- or x-ray) surveys. Due to the latter fact the properties of the selected BL Lacs have been rather specific and not representative of the BL Lac class.

To avoid the problems caused by single frequency surveys, new BL Lac samples have been constructed during the last decade by combining large radio- optical- and x-ray surveys. The SDSS survey has proved to be very useful in this respect. Combined with information from radio- and X-

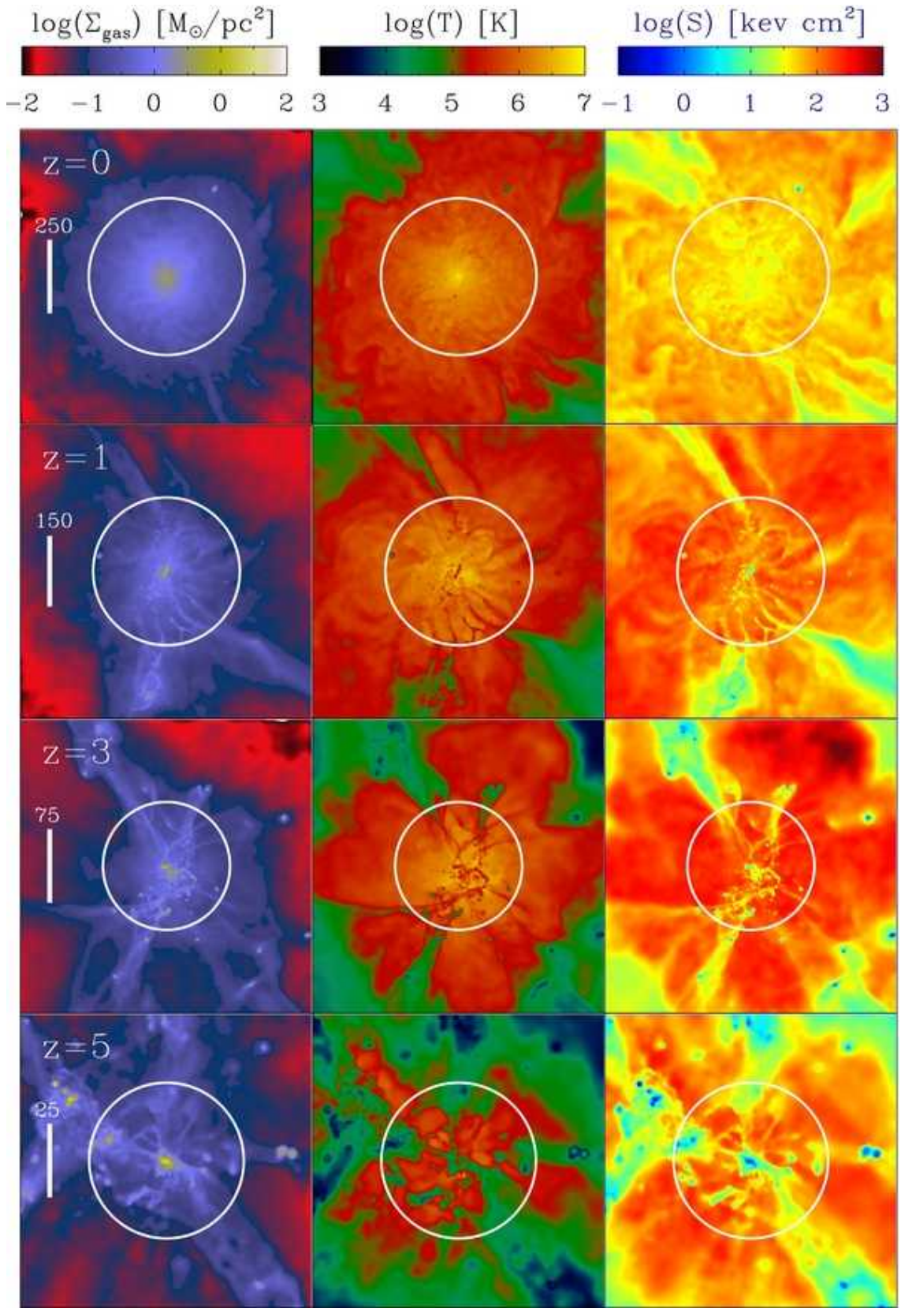

Fig. 1: Evolution of gas surface density (left panel), the mass-weighted mean gas temperature (middle panel) and the mass-weighted mean gas entropy (right panel) for a high resolution simulation of an early-type galaxy (Halo A2) at redshifts z=0, z=1, z=3, z=5 from top to bottom. The length scale of each panel is depicted by the white bar in kpc, with each panel representing a slice with depth 100 kpc centered at the position of the central stellar component and binned with 256^2 pixels. Adapted from Johansson, Naab & Ostriker, 2012, ApJ, 754, 115.

ray surveys, the SDSS survey has been used to construct new BL Lac samples with up to several hundreds of targets. These samples contain both already known and new BL Lacs. Strictly speaking, the latter should be considered as BL Lac {\em candidates} as their BL Lac status needs to be confirmed by further studies.

Kari Nilsson and colleagues are conducting a detailed study of one of the SDSS-based BL Lac samples compiled by Collinge et al. (2005 AJ, 129, 2542) to confirm the BL Lac status of the candidates. This sample covers an area of 2850 square degrees in the sky and has 240 candidates selected by their optical properties only. They obtained high signal-to-noise polarimetry of 185 targets in the sample using the ESO NTT, Calar Alto 2.2 m and NOT telescopes (Heidt & Nilsson 2011 A&A, 529, 162). The main result from this polarization survey was that a high fraction of targets (~70%) were significantly polarized (**Fig. 2**), thus providing further evidence of their BL Lac status. This shows that the original selection was very effective at selecting BL Lacs. To check the BL Lac status of unpolarized targets and to weed out any remaining galactic targets, they are currently studying the variability, host galaxies and broadband spectra of the sample targets.

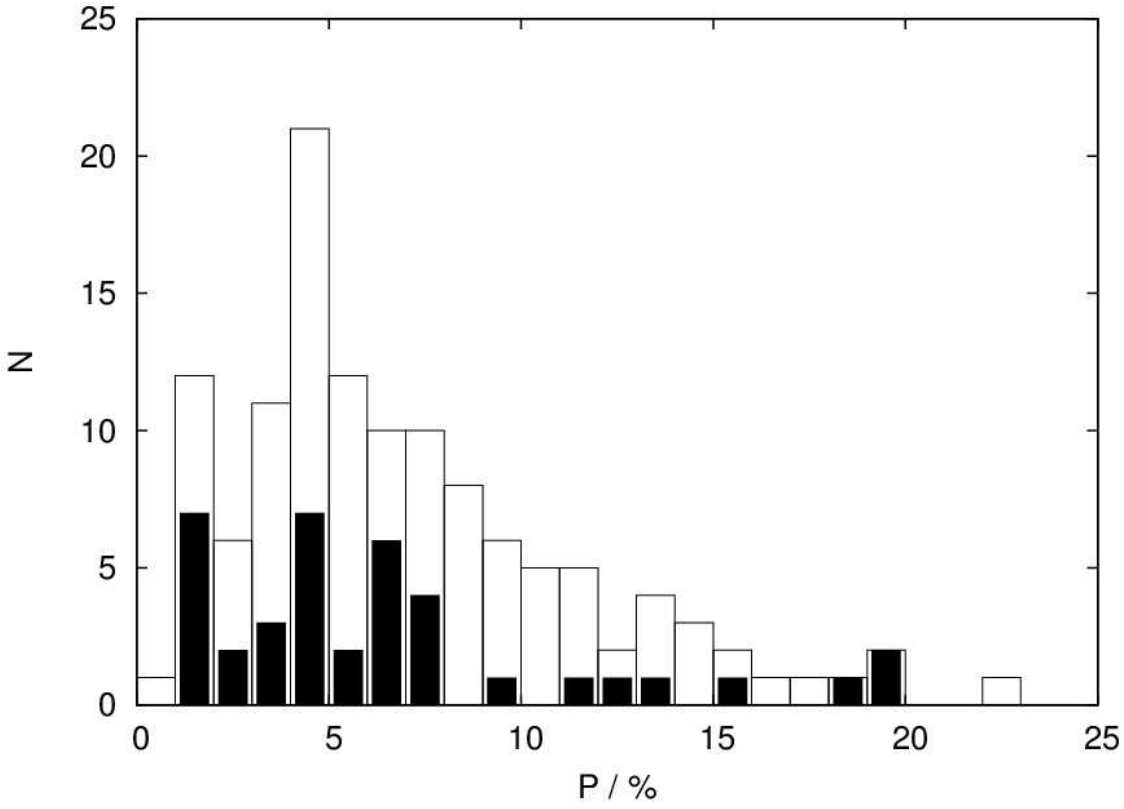

Fig. 2: Distribution of the degree of polarization of the sample targets. Black bars indicate previously known BL Lacs.

The low-mass end of the black hole – bulge relation in quasars

The relation between the black hole mass (BH) and the host galaxy mass in quasars has until now been probed only in a limited parameter space, namely at M(BH) ~10^9 Msun and M(host) ~10^{12} Msun. Recently, **Jari Kotilainen** and colleagues studied 26 quasars lying in the low-mass end of the relation, down to M(BH) ~107 Msun. They selected quasars from the SDSS and HST-FOS archives, requiring modest virial M(BH). They imaged the sources in the H band at the Nordic Optical Telescope. The quasar host galaxies were resolved in 25 out of 26 observed targets. Host galaxy

luminosities and stellar masses were computed, under reasonable assumptions on their star formation histories. Combining these results with those from their previous studies, they managed to extend the sampled parameter space of the M(BH)-M(host) relation in quasars. The relation holds over 2 dex in both parameters (**Fig. 3**), similarly to what is observed in low-luminosity AGN and in quiescent galaxies. For the first time, they were able to measure the slope of the M(BH)-M(host) relation in quasars, and find that it is consistent with the linear case (similarly to what is observed in quiescent galaxies). No evidence was found of a population of massive BHs below the relation.

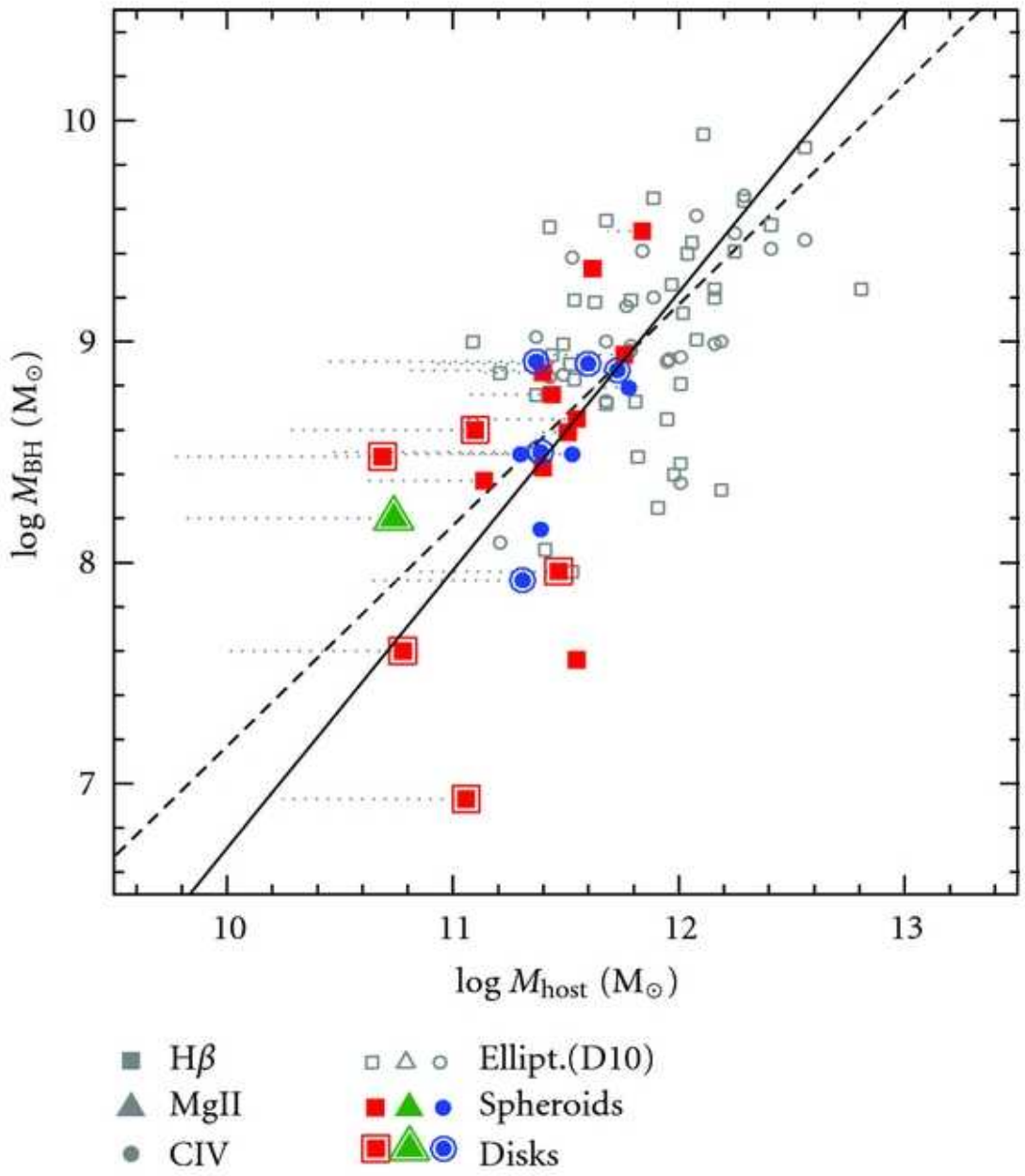

Fig. 3: The M(BH)-M(host) relation in the objects in our sample (filled symbols), as compared with the z<0.5 sample (empty symbols) and the local relation (M(BH(/M(host) ~0.0015). Squares, triangles, and circles refer to M(BH) estimates derived from Hbeta, MgII and CIV, respectively.

Photometric properties of nearby galaxies

The studies of **Eija Laurikainen** have focused on (i) a large survey of nearby galaxies based on Spitzer Space Telescope observations at mid-IR, and (ii) on early-type disk galaxies in the near-IR. The near-IR studies have used Near-IR S0 galaxy Survey (NIRS0S) for bright S0s, and SMAKCED collaboration data to study dE/dS0 galaxies in the Virgo cluster.

NIRS0S: The recently published NIRS0S Atlas (Laurikainen et al. 2011, MNRAS 418, 1452) includes new detailed morphological classifications of nearly 200 S0-S0/a galaxies in the near-IR. A new lens type, 'barlens', was discovered (**Fig. 4**), expected to be a key for understanding the bar evolution as well as bar induced secular evolution in galaxies. As one of the main results of NIRS0S, a revised Hubble tuning fork was suggested, called 'parallel sequence classification', in which S0s are classified as S0a, S0b, S0c, parallel to the Hubble spiral sequence. The same conclusion has been made nearly simultaneously by two other groups. This is the first time that observational evidence for this old idea has been given. During her one month stay in Marseille theoretical studies of barlenses were started, in collaboration with Athanassoula and Bosma.

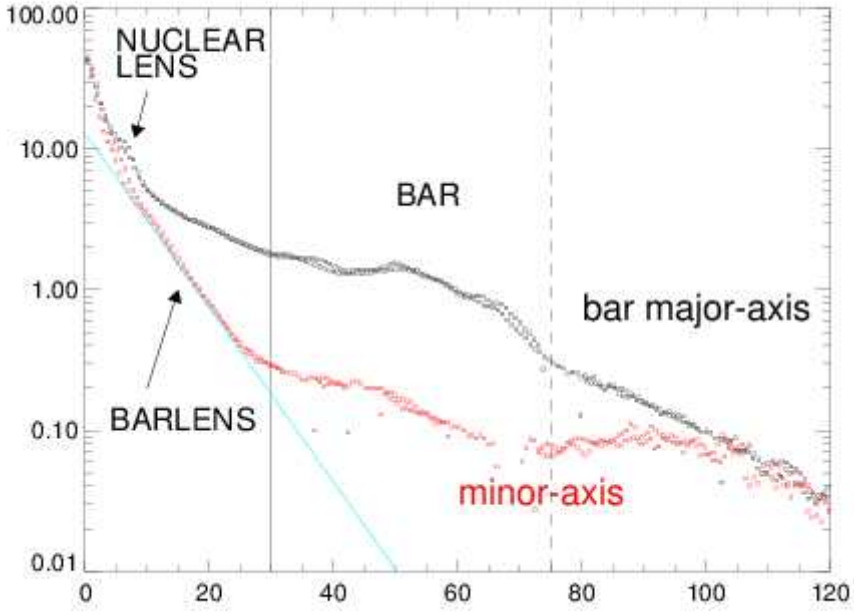

Fig. 4.

VIRGO: As part of the revised Hubble tuning fork scenario it has been suggested that dwarf early-type galaxies, dEs and dS0s, are red and dead former Scd-Im galaxies, in a similar manner as S0s are considered as red and dead Sa-Sc galaxies. Recent results by Janz et al. (2012, PhD thesis) are consistent with this picture. Similar morphological analysis, based on multi-component decompositions as performed previously for the bright S0s, was made also for the dE/dS0s in the Virgo cluster: it was found that a large majority of these galaxies have disk-like features, in terms of a second component in the surface brightness profile, or more directly, manifested as faint bars, spirals and lenses.

S4G: Laurikainen is a core-team member of the S4G project (The Spitzer Survey of Stellar Structure in Galaxies), which was awarded 627 hours of Spitzer Exploration Science time for 2009-

2011. Images at 3.6 and 4.5 micron were obtained, and the structures analyzed performed as one of the four main pipelines, in which she is involved. Progress has been made in many research projects, in particular related to thick disks, disk truncations, and on interpreting the origin of the radiation at the observed wavelengths (published in 6 articles in 2011/2012). For example, in M100, extending the optical and near-IR wavelengths to mid-IR and fitting the spectral energy distributions, it appeared that stellar population ages and stellar mass-to-luminosity (M/L) ratios are underestimated if the mid-IR wavelength region is omitted. As an example of the edge-on galaxy studies NGC 4013 can be mentioned, which has a thin disk and two thick disks. The second thick disk was explained to have formed from the first thick disk by dynamical heating in a merger process at an early stage of galaxy formation.

On the use of the Virial Theorem in Milky Way studies

A recent claim in the literature cast heavy doubt on the use of the Virial Theorem in Milky Way studies. This classical theorem is widely used in astronomy and physics, and relates the potential and kinetic energies of gravitational systems to each other in a simple and very useful way. **Chris Flynn** and colleagues showed that this recent claim was wrong, both by analytical means, and by simulations. The claim had been made that the determination of the gravitational field of the Milky Way using the Virial Theorem was unjustified, casting doubt on the whole dark matter picture, but this they were able to show is incorrect.

Oort cloud comets

Chris Flynn and colleagues modelled the flux of Oort cloud comets into the inner solar system. They took into account the tidal field of the Milky Way in a much more realistic way. The influx of comets is quasi periodic, due mainly to the motion of the Sun inwards and outwards in the Milky Way. There have been many claims over the years that periodicities in the cratering record of the Earth (which would come in bursts every 25-35 Myr) are related to the tidal field effect of the Milky Way on the Oort cloud. Their simulations show that such claims should be interpreted with caution, as the periodicities they get are too long (40-45 Myr) and show considerable variation from cycle to cycle.

Interstellar Medium, Star Formation and Stellar Astrophysics

From dark nebulae to stars

Jorma Harju and collaborators have studied early stages of star formation in dense molecular clouds in the framework of the project "Initial stages of star formation - research utilizing ESO's radio telescopes and advanced modelling" funded by the Academy of Finland. The main objective is to gain understanding of how molecular clouds fragment into dense cores and how cores evolve under their self-gravity. The work involves observations of molecular lines and thermal dust emission which are interpreted through comprehensive physical models including the chemistry and radiative transfer calculations.

One of the targets studied recently is the Orion B9 region which is likely to represent a very early stage of the formation of a stellar cluster. Continuing from a survey using the LABOCA bolometer array on the Atacama Pathfinder EXperiment (APEX), Miettinen et al. (2012, A&A 538, A137) observed the region at high angular resolution in the dust continuum and spectral lines using the SABOCA bolometer (350 micron) and the APEX/SHFI heterodyne receiver. The observations resulted in improved estimates of the physical parameters and evolutionary stages of the prestellar and protostellar cores in the region. One of the starless cores was found to contain several subcondensations (**Fig. 5**), which suggests that a dense core can fragment through Jeans-type instability during the prestellar phase to form a group of stars as opposed to the sequential formation scenario. The chemical abundances show surprisingly large variations from core to core. This indicates that the rates of chemical evolution can be different in individual cores belonging to the same complex, depending on their physical conditions. The result emphasizes usefulness of chemistry modelling when molecular line observations are interpreted.

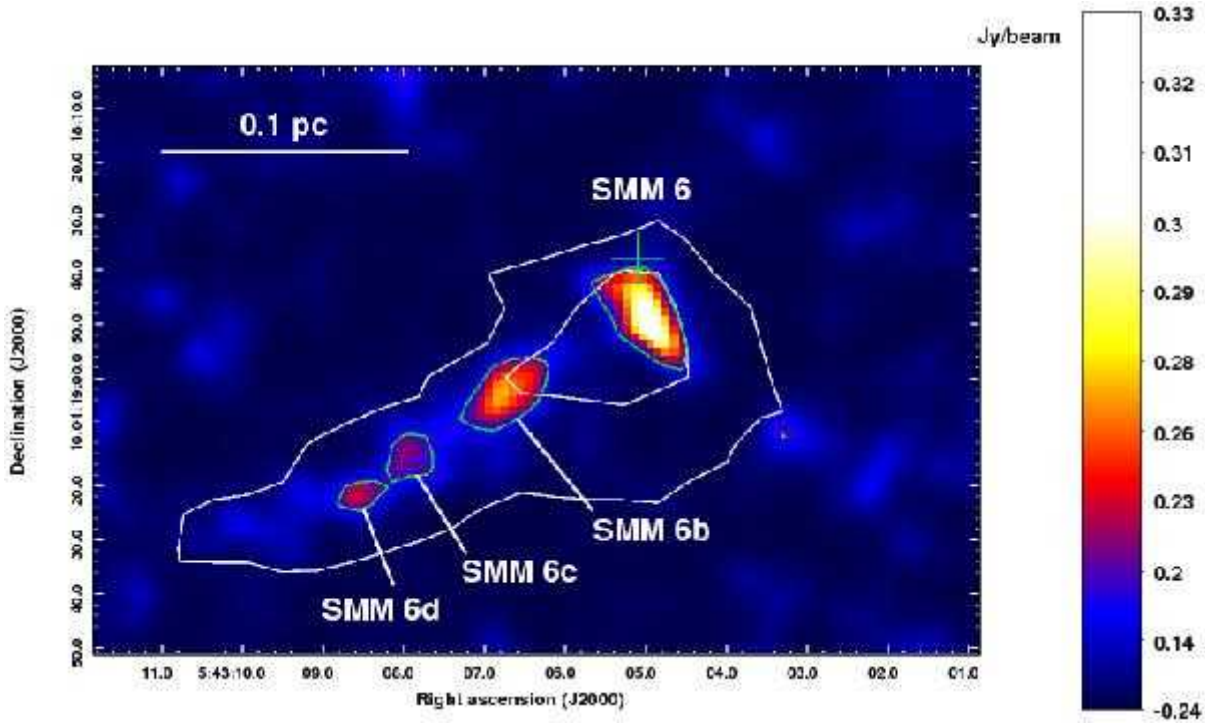

Fig. 5: 350 & 956 micron SABOCA image of the fragmented pre-stellar core SMM 6. The fragments may collapse to low-mass stars or brown dwarfs.

The gas kinetic temperature is one of the central parameters affecting the stability of a dense molecular cloud core. The most frequently used temperature probe is the ammonia molecule (NH3) and its inversion lines. Juvela et al. (2012, A&A 538, A133) examined the accuracy of the temperature estimates derived from ammonia spectra. Synthetic NH3 spectra were calculated from a series of spherically symmetric cloud models, low-mass Bonnor-Ebert spheres, with different radial temperature profiles. The synthetic spectra were analysed under the normal assumption used in observational studies that all the hyperfine line components with different optical thicknesses trace the same volume of gas. For high signal-to-noise observations, the estimated gas kinetic temperatures are within ~0.3 K of the real mass averaged temperature and the column densities are correct to within ~10%. However, if the cores are optically very thick, there are no longer guarantees of the accuracy of the estimates from ammonia. These advantages and limitations should be noticed when using ammonia as a thermometer of molecular clouds.

Cataclysmic Variables

Seppo Katajainen has continued studies of magnetic Cataclysmic Variables (CVs) to find new subclasses among CVs, in addition to those subclasses which are already known as "magnetic" CVs, i.e. Polars (AM Hercules stars) and Intermediate Polars (DQ Hercules stars). One example of new possible subclasses among mCV-class is a class of SW Sex stars. Circular polarization survey of these stars has been continued in 2011. They have found a few examples of SW Sex stars which emit circularly polarized light, and definitely have magnetic field strength comparable to Polars and IPs. This emphasizes their original hypothesis that SW Sex stars are possible progenitors for Polars, and thus these results will have impact on binary evolution models, and SN Ia evolution models.

They have also continued studies to reveal more highly magnetic systems among Intermediate Polars(IPs), where previously only few randomly found targets have been known to be strongly magnetic. They have furher found in analysis of VLT data (Southern Polarization Survey for Intermediate Polars) several new IP systems which emit circularly polarized light up to several percent level (Katajainen et al. 2012, submitted). Observed circular polarization is necessarily due to the cyclotron emission process near the surface of the white dwarf and thus strong evidences of their magnetic nature.

V381 Vel is a good candidate for IP system, sometimes also classified tentatively as a new polar system candidate. It has shown at least two different periods in photometry and spectroscopy, and thus its classification as polar is not clear, and it could be thus more likely an IP system. V381 Vel emits strongly circularly polarized light in the B-band (from -5 % to +2 %) and R-band (-3 % to +2 %), in VLT FORS observations. The main question here is if those IPs and Polars (the very strongly magnetic CVs) will have a commom origin and common evolutionary paths, and particularly the question: are IPs the progenitors of Polars?

In addition to IPs, and SW Sex stars they have also studied a sample of the brightest AM CVn stars with polarimetry. These stars are so called ultra-compact binary systems, and they are binaries where there is a white dwarf as a primary component and a compact helium star (or another white dwarf) rotating as a secondary star. Their orbital periods are the shortest known in any binary stars, in most extreme cases the orbital period is in the range of 5 - 10 minutes. These systems are also very strong sources for gravitational waves in the sky, which will be possible to observe within few years when the NASA/ESA LISA satellite will be launched. They have observed in these stars hints of circular polarized light and thus evidences of their possible magnetic fields.

Multicolor polarimetry of exoplanet HD189733b

Multicolor polarimetric measurements (UBV bands) by **Andrei Berdyugin** and colleagues for the hot Jupiter HD189733b made on the NOT in 2008 clearly confirmed their previously reported detection of polarization in the B band (Berdyugina et al. 2008). The wavelength dependence of polarization indicates the dominance of Rayleigh scattering with a peak in the blue B and U bands of 10^{-4} – 10^{-5} and at least a factor of two lower signal in the V band (**Fig. 6**). The Rayleigh-like wavelength dependence implies a rapid decrease of the polarization signal toward longer wavelengths. They demonstrate that effects of incomplete cancellation of stellar limb polarization due to starspots or tidal perturbations are negligible as compared to scattering polarization in the planetary atmosphere. They compare the observations with a Rayleigh-Lambert model and determine radii and geometrical albedos for different wavelengths. It appears that the planetary atmosphere is optically thin in the visible and thick in the near UV. This result finally establishes polarimetry as a reliable means for direct studying exoplanetary atmospheres. (Berdyugina et al. 2011, ApJL, 728, L6).

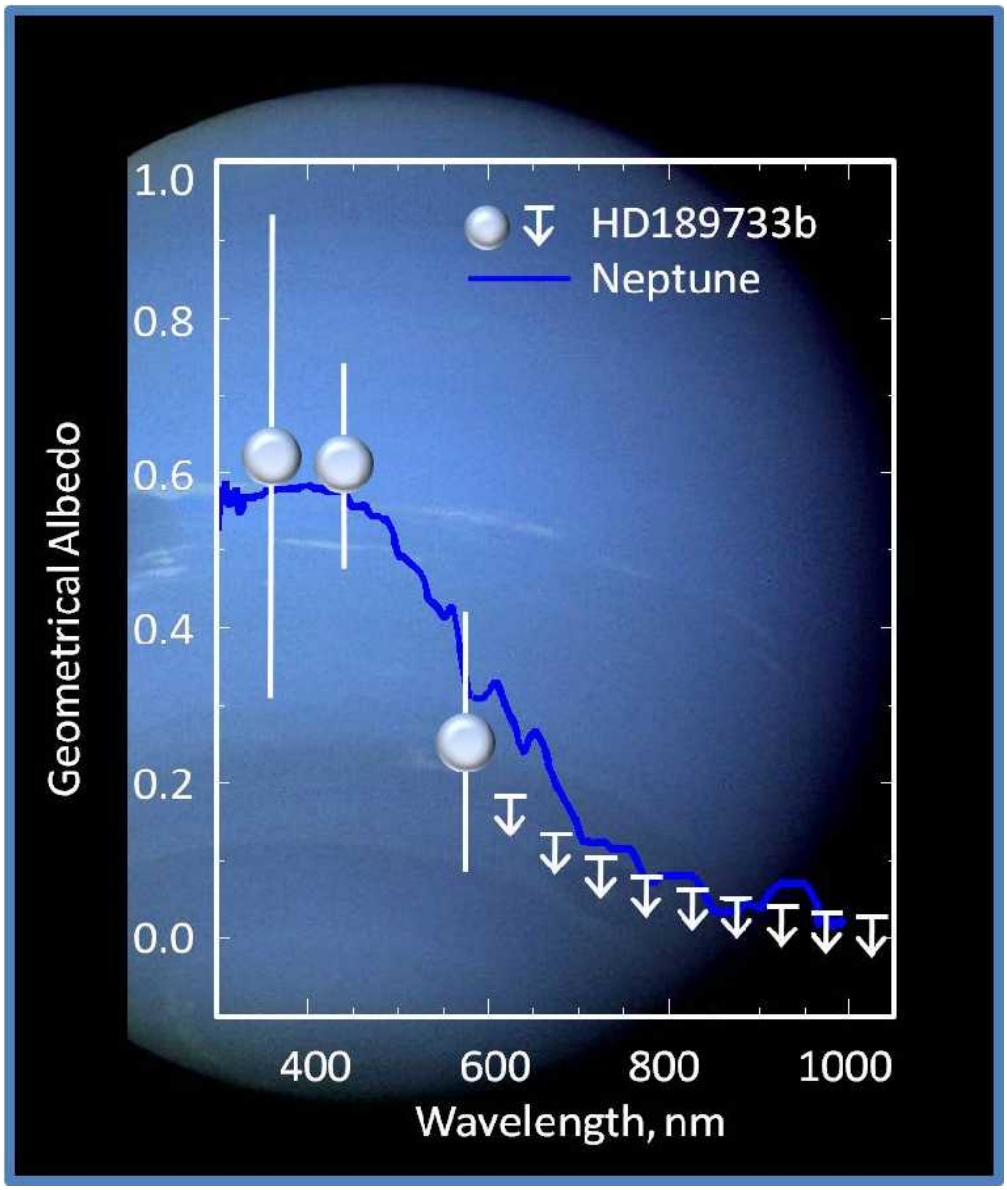

Fig. 6.

The interstellar magnetic field close to the Sun

The magnetic field in the local interstellar medium (ISM) provides a key indicator of the galactic environment of the Sun. **Andrei Berdyugin** and colleagues have studied the interstellar magnetic field (ISMF) in the solar vicinity using polarized starlight for stars within 40 pc of the Sun in the galactic center hemisphere. A novel method of deducing the best fitting ISMF direction to the polarization position angles yields an ISMF direction towards $\ell, b = 49^\circ - 20^\circ, 28^\circ - 20^\circ$. This direction is consistent with the ISMF direction found from the center of the ribbon of energetic neutral atoms discovered by IBEX spacecraft. An angle of ~78° is found between the ISMF direction and the flow of interstellar gas and dust through the very local ISM. This angle and the flow kinematics suggest the Sun is embedded in a fragment of the Loop I super-bubble. An ordered component of the ISMF direction is identified towards the tangential sightlines through Loop I. This component corresponds to the upper limit of the distance-polarization relation for stars in the same region, and extends to within 8 pc of the Sun. It is used to identify a slow curvature in the nearby ISMF of ~ 0.3° per parsec, and a turbulent component in the ISMF characterized by position angle variations of ~ 23°. The directionality of the ISMF found over local spatial scales of 8 – 200 pc suggests that the ISMF shaping the heliosphere is more similar to inter-arm than spiral-arm magnetic fields. The polarization ISMF direction is also consistent with small-scale spatial asymmetries detected in GeV-TeV galactic cosmic rays. The peculiar geometry relating the cosmic microwave background dipole moment, the heliosphere nose, and the ISMF direction, is well supported by this study. (Frisch et. al. 2011, ApJ, submitted).

Stellar magnetic activity

Thomas Hackman participates in an international research project "Active Suns", funded by the University of Helsinki. The observational part of this research contains studies on spot activity of late-type stars based on Doppler imaging using spectroscopy and spectropolarimetry, and time-series analysis of photometry. The methods utilise the fact that large spots on the surface of a star will produce measurable variations in the brightness and photospheric spectral lines. In Doppler imaging the surface structure, e.g. a temperature or magnetic field map, is recovered applying inversion methods on a series of high resolution spectrometric or spectropolarimetric observations. By applying time series analysis on stellar light curves one can study both short and long term variations in the spot activity of the star.

In 2011 the efforts of Doppler imaging of the RS CVn star II Peg were continued (Lindborg et al. 2011; Hackman et al. 2011; Hackman et al. 2012). The observations were collected with the SOFIN spectrograph mounted at the Nordic Optical Telescope and time series spans from 1994-2011. Furthermore, they used GTO programme data from HARPSPol@ESO3.6 through the cooperation with Uppsala University. The resulting temperature maps in general show one or two large spot regions at high latitudes. The longitude of the main spot region clearly drifts in the frame of the rotation period , which is locked to the orbital period in this binary star (**Fig. 7**). The drift can be explained by a dynamo wave propagating in the longitudinal direction.

The period analysis method, the CPS (Continuous Period Search), was applied to Johnson V-photometry collected with automated photometric telescopes. The study of the young solar analogue HD 116956 was published (Lehtinen et al. 2011), while studies on four other stars were under work (Lehtinen et al. 2012; Hackman et al. 2012, in prep.; Jetsu et al. 2012, in prep.,

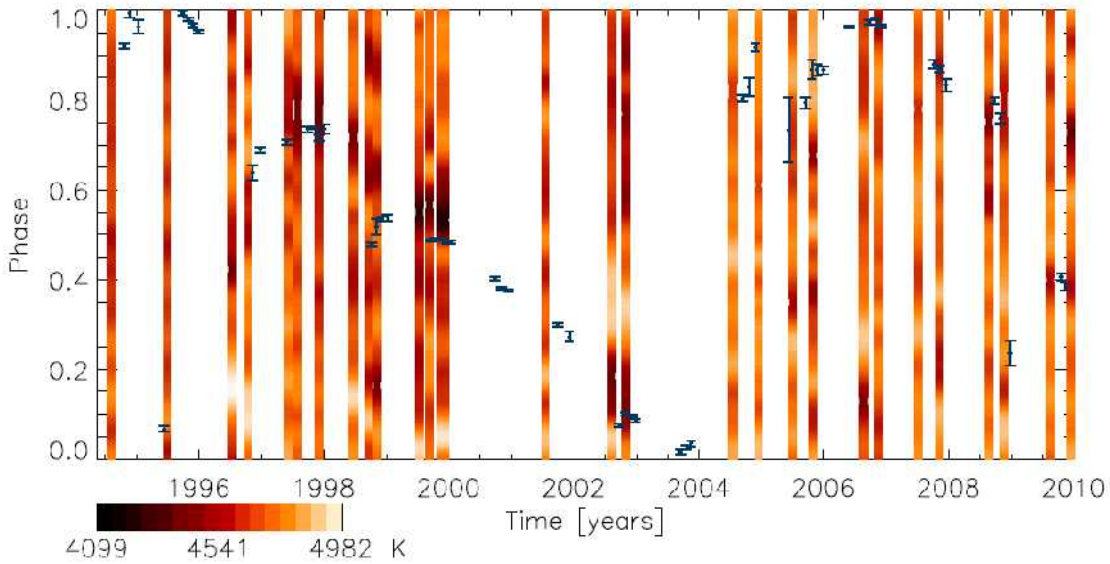

Fig 7. Average surface temperature, calculated from the temperature maps over the whole latitude range, as a function of phase. Each stripe represents one Doppler image. The points with error bars mark the photometric minima. (Hackman et al. 2011). The plot is a "longitudinal equivalent" to a solar butterfly diagramme, The drift of the main active region during 1995-2003 can be explained by a dynamo wave.

Kajatkari et al. 2012 in prep.). The most important findings include persistent active longitudes, Dynamo waves and estimates of differential rotation and the time scales of changes in the spot configurations.

Hackman also participated in theoretical studies exploring alternative models for spot generation on late-type stars. The preliminary findings show that cool (and hot) spots can occur on late-type stars simply as a result of vortices arising from rapid rotation and convection, i.e. without any magnetic fields (Käpylä et al. 2011; Mantere et al. 2011).

Studies of accreting neutron stars with strong magnetic field

Sergey Tsygankov and collaborators from Germany and Russia have investigated X-ray pulsar RX J0440.9+4431. Before 2010, it belonged to the few persistent low-luminosity binaries with Be companions which harbor a slowly rotating neutron star (pulse period ~202.5 s). The first evidence of the pulsar outburst activity in X-rays was found in March 2010 by the MAXI all-sky monitor on board the International Space Station. During the following outburst, in September 2010, ESA's INTEGRAL satellite was used to investigate the properties of RXJ0440.9+4431 in hard X-rays for the first time. Another outburst was detected by NASA's Swift observatory in January 2011.

Taking into account that the peak luminosities of all three outbursts were relatively low (allowing to consider them as Type I outbursts), and that all outbursts were roughly equally spaced in time, the orbital period of RXJ0440.9+4431 was estimated to ~155 days. This value is in good agreement with the period of about 150 days derived from the Corbet Pspsin - Porbit correlation.

Spectral analysis of data obtained with INTEGRAL during the 2010 September outburst revealed a ~32 keV cyclotron resonant scattering feature in the source spectrum (**Fig. 8**), that allowed to estimate the magnetic field strength of the neutron star as $B = 3.2 \times 10^{12}$ G . It makes RX

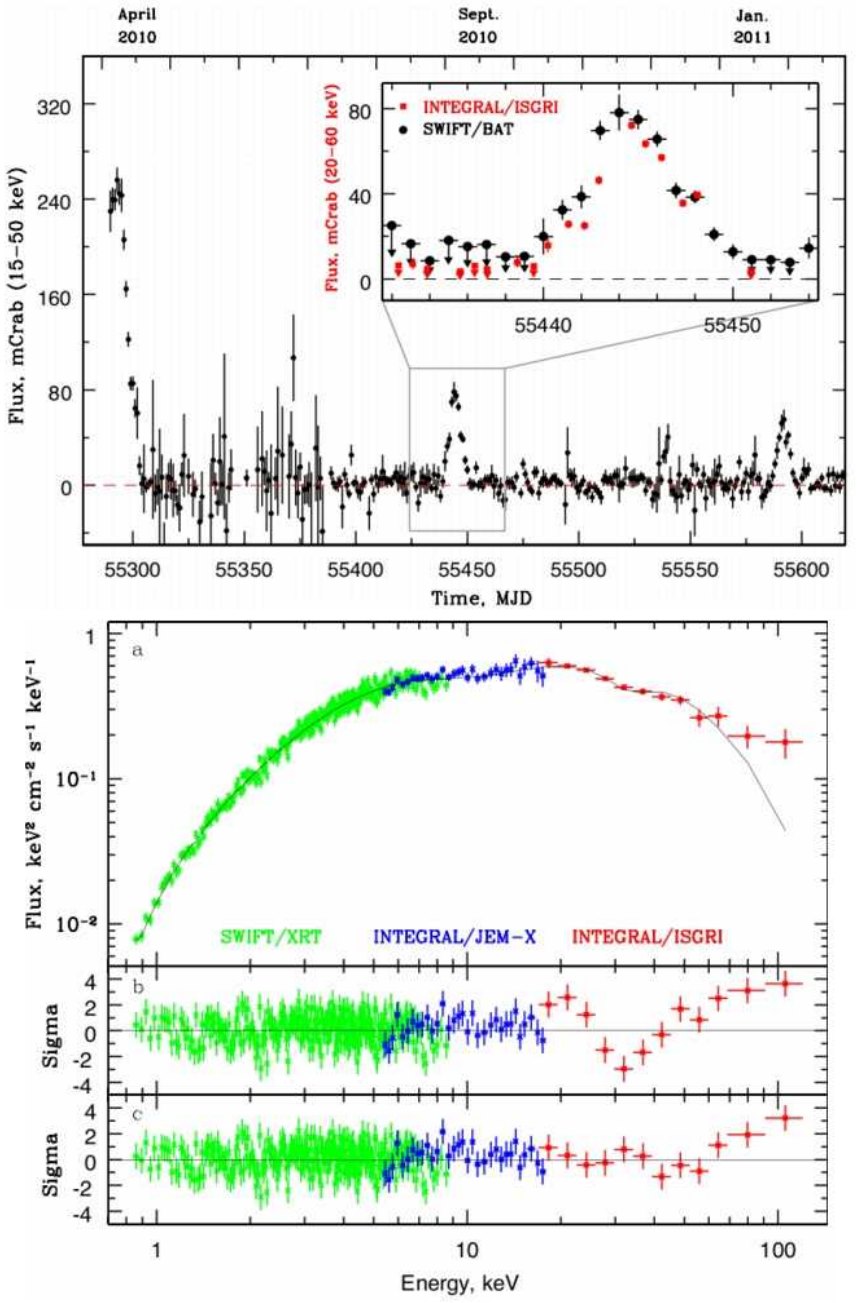

Fig. 8: The top panel shows the lightcurves obtained by Swift (black) and INTEGRAL (red). Below the composite spectrum is shown using (a) data from Swift (green), INTEGRAL/JEM-X (blue) and INTEGRAL/ISGRI (red). The residuals to the fit in units of sigma are shown without (b) and with (c) a 32 keV cyclotron absorption line.

J0440.9+4431 only the second persistent Be/XRP system (after X Persei) with known magnetic field strength and orbital period. For more details see Tsygankov et al. 2012, MNRAS, in press. This research also made the INTEGRAL Picture of the month for April 2012.

Ingredients of stellar magnetic activity: differential rotation

Gaseous bodies, like the stars, can have different rotation rates at different latitudes. In the Sun the rotation velocity of the visible surface depends strongly on the latitude; the rotation of the solar equator is approximately 30% shorter than the period at the poles. This differential rotation is one of the main elements in the dynamo models, and together with the helical turbulence and meridional flow it is responsible for the main features of the solar and stellar magnetic activity. For proper understanding of the creation of solar and stellar magnetic fields it is important to study differential rotation also on other stars than the Sun. One of the main lines of investigation by **Heidi Korhonen** is to study stellar differential rotation, using both observations and dynamo simulations.

From the observational side Korhonen and her collaborators have been studying differential rotation from the high precision light-curves provided by the Kepler satellite via a Guest Observer programme (paper in preparation Berdyugina et al.), and from spectra of a K giant star zeta Andromedae (Khovari et al. 2012, A&A 539, A50). In the study of zeta And Doppler imaging technique was used to study three slightly overlapping independent spectroscopic data sets from different observing sites, among them the UVES spectrograph at ESO VLT. Each dataset covers one full stellar rotation with good phase coverage, which results in a continuous coverage of almost three stellar rotations, and creates a unique opportunity to study surface differential rotation. The cross-correlation of all possible image pairs reveals signs of weak differential rotation with strength about 2% of the solar value. This is weaker differential rotation than the theory predicts.

In a theoretical study on measurability of stellar surface differential rotation Korhonen used snapshots from dynamo models to investigate how well the cross-correlation method reproduces the latitudinal rotation rates used in the dynamo calculations (Korhonen & Elstner, 2011, A&A 532, A106). Their investigation showed that the cross-correlation method works well when the time difference between the maps is appropriate for recovering the surface differential rotation, and, importantly, if small-scale fields were included in the dynamo calculations (see **Fig. 9**). Using only large-scale dynamo field the solution was dominated by the geometry of the dynamo field and the input rotation law was not recovered from the snapshots. Actually, the results in these cases showed much smaller surface differential rotation, than what wasused in calculating the dynamo models. On the other hand, with additional injection of small-scale fields the input surface rotation law was well recovered. This rises the question whether the large starspot seen in active stars can actually be created by small scale fields. If they are manifestations of the large-scale dynamo field, then according to this study one would not even expect them to follow the surface differential rotation.

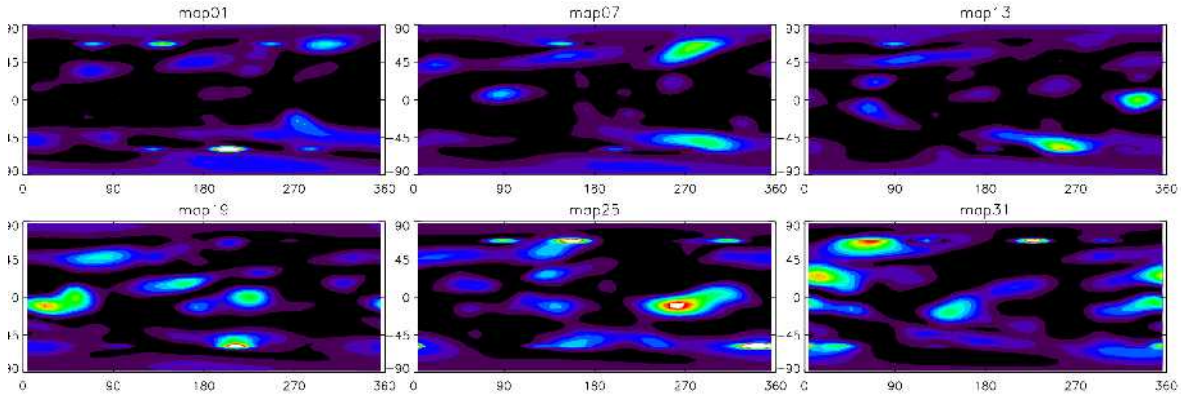

Fig. 9: Examples of snapshots of dynamo simulations showing magnetic spots tracing stellar differential rotation.

Instrumentation and Methods

High Precision Polarimeter DIPOL-2

Vilppu Piirola has received a new grant from Kiepenheuer-Institut Für Sonnenphysik (KIS) to build a second copy of the high precision polarimeter DIPOL-2. The successful commissioning and operation of the DIPOL-2 polarimeter have opened new prospects for the exploration of astrophysical objects in polarized light and for the collaboration of FINCA and KIS. The DIPOL-2 is currently operated remotely at the KVA 60 cm telescope on La Palma, Spain, and collects valuable scientific data on nightly basis at the 10^{-5} sensitivity level in the degree of polarization (see **Fig. 10**). Therefore, the parties have agreed to expand and deepen the existing collaboration in the field of astrophysical polarimetry, including the testing and operating the new polarimeter InnoPol, being built by KIS and the University of Hawaii. Both of these new polarimeters will be used at the telescopes of the Haleakala Observatory, Maui, Hawaii. Together with the operating DIPOL-2 at the KVA-60, they will constitute a unique telescope network dedicated for polarimetric studies, and will open significant new possibilities for the joint research.

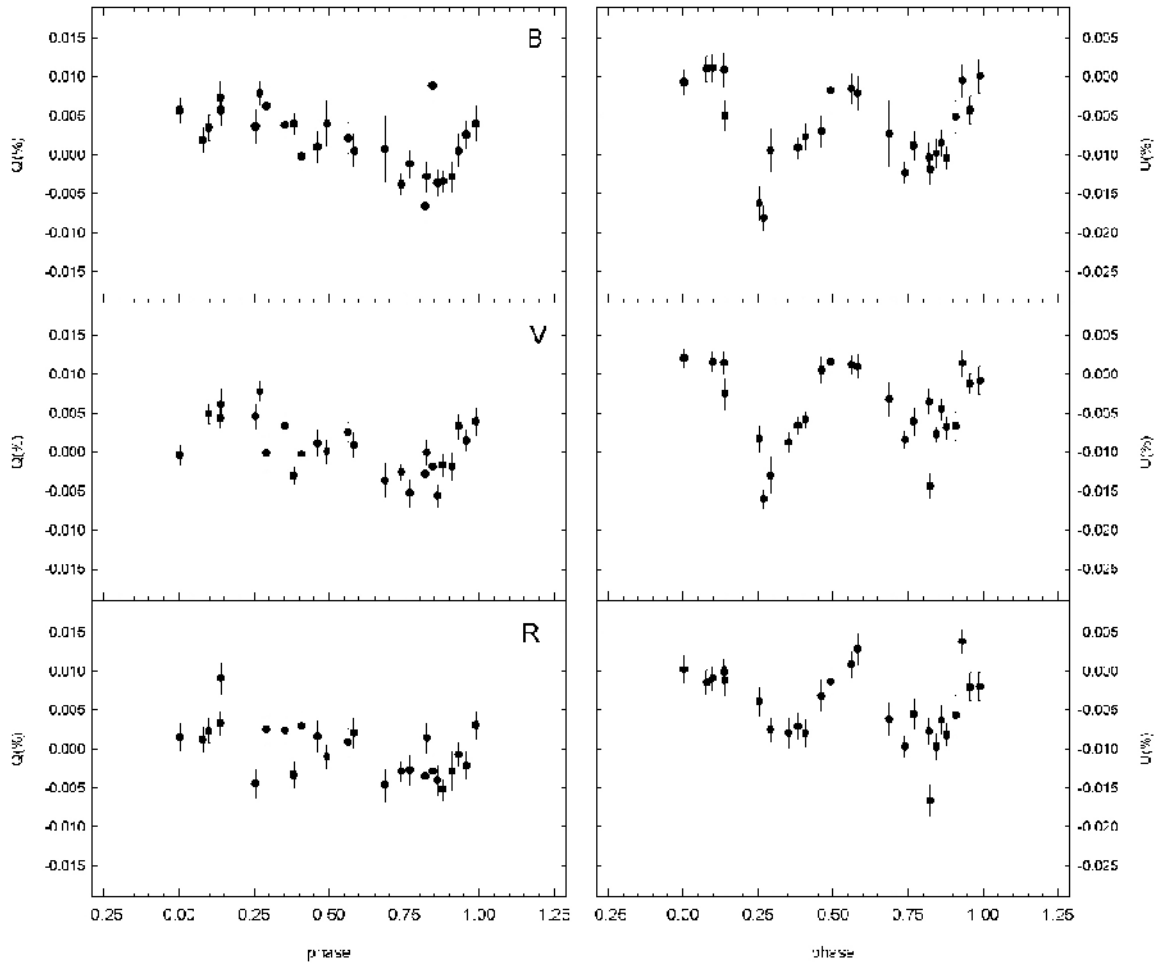

Fig. 10.: Example of high precision polarimetry of Algol with DIPOL-2 at the remotely operated KVA-60 telescope on La Palma. The data obtained simultaneously in three spectral passbands (BVR) are expressed in terms of the polarization vector components Q and U, and show clearly the phase-locked polarization variability over the binary orbital period, due to scattering of photons by free electrons in the circumstellar plasma. The measurements are an order of magnitude more accurate than available earlier for this object (from Piirola and Berdyugin, in preparation).

Organization and Personnel in 2011

The Institute Board

Chairman:	Leo Takalo, Docent (University of Turku)
Vice Chairman:	Heikki Salo, Professor (University of Oulu)
Members:	Pasi Hakala, Docent (University of Turku, FINCA staff)
	Juhani Huovelin, Docent (University of Helsinki)
	Hannu Koskinen, Professor (University of Helsinki)
	Jorma Kyyrä, Vice Rector (Aalto University, Helsinki)
	Juri Poutanen, Professor (University of Oulu)
	Aimo Sillanpää, Docent (University of Turku)
	Merja Tornikoski, Professor (Aalto University, Helsinki)

The Scientific Advisory Board

Chairman:	Prof. Johannes Andersen (Nordic Optical Telescope, Spain)
Members:	Dr. Susanne Aalto (Chalmers University of Technology, Gothenburg, Sweden)
	Prof. Claes Fransson (Stockholm University, Sweden)
	Prof. Johan Knapen (Instituto de Astrofisica de Canarias, La Laguna, Spain)
	Dr. Bruno Leibundgut, European Southern Observatory, Garching, Germany)
	Prof. Nikolai Piskunov (University of Uppsala, Sweden)
	Dr. Marianne Vestergaard (University of Copenhagen, Denmark)

Personnel in 2011 (stationed at the University of Turku, unless otherwise mentioned.)

Director:	Jari Kotilainen
Professor emeritus:	Mauri Valtonen
University Researchers:	Andrei Berdyugin
	Chris Flynn (on leave of absence)
	Thomas Hackman (Helsinki)
	Lauri Haikala (from 1.10.2011; Helsinki)
	Pasi Hakala
	Jorma Harju (from 1.10.2011; Helsinki)
	Peter Johansson (until 31.8.2011; Helsinki)
	Heidi Korhonen (on leave of absence from 1.8.2011)
	Eija Laurikainen (Oulu)
	Jukka Nevalainen (Helsinki)
	Kari Nilsson
	Vilppu Piirola
Post-doctoral Researchers:	Tomi Hyvönen
	Seppo Katajainen
	Aleksey Medvedev (Oulu)
	Veli-Matti Pelkonen (from 1.7.2011; Helsinki)
	Elina Nieppola (on leave of absence from 29.7.2011; Aalto)
	Ricardo Salinas (from 1.11.2011)
	Sergey Tsygankov (from 1.9.2011; Oulu)
PhD students:	Kalle Karhunen (1.5.-31.10.2011)

Teaching in 2011

The researchers of FINCA give a number of courses in their Universities. The basic courses are taught every year, while intermediate and advanced courses are given on average once in two years. Many courses are given in English if required.

Introductory courses:

Thomas **Hackman**, Havaitsevan tähtiteteen peruskurssi I (Basic course in optical astronomy), University of Helsinki, 4 credits

Thomas **Hackman**, Universum nu (Universe now), University of Helsinki, 4 credits

Intermediate courses:

Jari **Kotilainen**: Galaksien kehitys I (Evolution of Galaxies I), University of Turku, 4 credits

Kari **Nilsson**, Structure and Evolution of Stars I, University of Turku, 8 credits,

Advanced courses:

Andrei **Berdyugin**: Astro-photometry and polarimetry, University of Turku, 4 credits

Chris **Flynn**, Galactic Dynamics, University of Turku, 6 credits

Lauri **Haikala,** Jorma **Harju** and Oskari Miettinen: Interferometry, University of Helsinki, 7 credits

Peter **Johansson**: Advanced dynamics in Astronomy (co-lectured with Prof. Karri Muinonen), University of Helsinki, 7 credits.

Heidi **Korhonen**, Lecturer and tutor in the ninth Neon Observing school, Molėtai Astronomical Observatory (Lithuania), July 14 - 27, 2011

Completed theses in 2011

Clay **Hambrick**, Ph.D thesis: The effects of ionizing radiation on the evolution of SPH-simulated galaxies, Department of Astrophysical Sciences, Princeton University (co-supervised by Dr. **Johansson** with Prof. Jeremiah Ostriker and Dr. Thorsten Naab).

Jarkko **Laine**, M.Sc. thesis: A study of truncated galactic disks using S4G data (supervised by Dr. Eija **Laurikainen** and Prof. Heikki Salo), University of Oulu

Carolin **Villforth**, Ph.D. Thesis: Variability in Active Galactic Nuclei: Understanding Emission Mechanisms and Unification Models, University of Turku (supervised by Dr. Kari **Nilsson**)

Organizing committees of conferences and other committee memberships

Thomas **Hackman**, Member of SOC for the conference ”Magnetic fields in stars and exoplanets” (7 th Potsdam thinkshop), August 22-25, 2011, Potsdam (AIP),

Peter **Johansson**, Head of the Astronomy and Space Physics division of the Finnish Physical Society

Seppo **Katajainen**, Secretary of The Finnish National Committee for Astronomy,

Seppo **Katajainen**, Finnish representative in ESO Users' Committee,

Seppo **Katajainen**, Chairman of the board, The Finnish Astronomical Society

Seppo **Katajainen**, LOC member in FinCOSPAR 2011 meeting (held in Kasnäs Archipelago Spa, Kemiö)

Heidi **Korhonen**, Member of OPTICON common Time Allocation Committee

Heidi **Korhonen**, Member of the SOC/LOC of FinCospar 2011 meeting

Jari **Kotilainen**, Finnish delegate, ESO Council, 2011-

Jari **Kotilainen**, FinCOSPAR2011, 31.8.-2.9.2011, chair of LOC/SOC

Eija **Laurikainen**, one of the main organizers of an international S4G (related to Spitzer Space Telescope observations) science meeting in Oulu, Finland, 11.-14.7.2011

Sergey **Tsygankov**, Panel member on compact objects, INTEGRAL observatory time allocation committee

Conference presentations and seminar talks

(I)= invited talk; (O) – oral presentation; (P) – poster

Thomas **Hackman**, Rädler-fest: alpha-effect and beyond, February 16-19, 2011, Stockholm (NORDITA), ”Photometric time series analysis and Doppler imaging of late type stars” (O)

Thomas **Hackman**, Physics days, March 29-31.3.2011, Helsinki, ”Observing magnetic activity of late-type stars” (P)

Thomas **Hackman**, Magnetic fields in stars and exoplanets (7 th Potsdam thinkshop), August 22-25, 2011, Potsdam (AIP), ”Spot activity of II Peg” (O)

Peter **Johansson**, "The UV background and the minimum mass of galaxies" 21.1.2011, Astrophysics seminar, Department of Physics, University of Helsinki (O)

Peter **Johansson**, "Numerical galaxy formation" 25.2.2011, Cosmology & Astroparticle seminar, Department of Physics, University of Helsinki (O)

Peter **Johansson**, "Termination of star formation in elliptical galaxies" 30.3.2011, The 45th annual meeting of the Finnish Physical Society, Helsinki (O)

Peter **Johansson**, "The UV background and the minimum mass of galaxies", 12.4.2011, Computational astrophysics group seminar, University Observatory Munich (O)

Peter **Johansson**, "Forming Early-type galaxies in LambdaCDM simulations", 21.4.2011, Ringberg Workshop on Galaxy formation 2011, Ringberg, Germany (I)

Peter **Johansson**, "Forming Early-type galaxies in LambdaCDM simulations" 22.6.2011, Insititute for Astronomy seminar, University of Edinburgh, UK (I)

Peter **Johansson**, "How to make elliptical galaxies dead and red" 31.8.2011, FinCOSPAR 2011, Kasnäs.

Heidi **Korhonen**, Feb 25 2011, Tuorla Observatory, Stellar activity seen with Kepler

Heidi **Korhonen**, Apr 12 2011, FINCA, Observing with ALMA

Heidi **Korhonen**, IAU Symposium 286: Comparative Magnetic Minima, October 3-7 2011, Mendoza, Argentina, Investigating Stellar Surface Rotation Using Observations of Starspots (I)

Heidi **Korhonen**, Extreme SolarSystems II, September 11-17 2011, Jackson Lake Lodge, USA, The Young Planet Hosting Triple System TYC 2627-638-1 (P)

Heidi **Korhonen**, FinCospar 2011, August 31- September 22011, Kasnäs, Finland, Detailed multi-wavelength look at FK Comae Berenices (O)

Heidi **Korhonen**, 7th Potsdam Thinkshop: magnetic fields in stars and exoplanets, August 22-25 2011, Potsdam, Germany, Do large starspots trace the real surface differential rotation? (O)

Heidi **Korhonen**, 7th Potsdam Thinkshop: magnetic fields in stars and exoplanets, August 22-25 2011, Potsdam, Germany, FK Comae - COCOA-PUFS: UV Spectroscopy of the King of Spin (O)

Heidi **Korhonen**, 7th Potsdam Thinkshop: magnetic fields in stars and exoplanets, August 22-25 2011, Potsdam, Germany, The magnetic field and variability of HgMn stars (P)

Jari **Kotilainen**, “The link between supermassive black holes and their host galaxies at low redshift”, 31.8.2011, FinCOSPAR 2011, Kasnäs (O)

Jari **Kotilainen**, “Nuclear Stellar Populations in Nearby Spiral Galaxies”, 11.11.2011, Tuorla Observatory seminar, University of Turku

Jari **Kotilainen**, “Nuclear Stellar Populations in Nearby Spiral Galaxies”, 14.11.2011, seminar at the

Department of Physics, University of Helsinki

Eija **Laurikainen**: seminar at Laboratoire d'Astrophysique de Marseille, June 2011; "Near-IR S0 galaxy survey" (O)

Eija **Laurikainen**: Spitzer Space Telescope (S4G) science meeting, Oulu, Finland, July 2011: 'Current status of Pipeline 4' (O)

Kari **Nilsson**, 29.4.2011, Tuorla Observatory, Optical support for MAGIC: Host galaxies

Veli-Matti **Pelkonen**, Meeting of the cold cores project, Helsinki, Finland 29.-31.8.2011
- Bolocam survey of a sample of cold Planck clumps (oral)
- (Herschel) Data reduction (oral, follow-up discussion chair)
- Planck Cold Clumps at High Galactic Latitude (oral)

Veli-Matti **Pelkonen**, FinCOSPAR 2011, Kasnäs, Finland, 31.8.-2.9.2011, Bolocam observations of Archeops detected cold clumps (P)

Veli-Matti **Pelkonen**, Planck Papers Workshop, Cambridge, UK, 12.9.15.9.2011
- Bolocam survey of a sample of Planck cold clumps (oral)
- Galactic cold cores: Cloud morphology and comparison with infrared data (oral)
- Planck Cold Clumps at High Galactic Latitude (oral)

Veli-Matti **Pelkonen**, MW2011: The Milky Way in the Herschel Era, Rome, Italy, 19.-23.9.2011, Bolocam observations of Archeops detected cold clumps (P)

Veli-Matti **Pelkonen**, 25.11.2011, University of Helsinki, Helsinki, Finland, Bolocam and Herschel survey of a sample of Planck cold clumps

Veli-Matti **Pelkonen**, 14.12.2011, Tuorla Observatory, Tuorla, Finland, Bolocam and Herschel survey of a sample of Planck cold clumps

Sergey **Tsygankov**, "The Extreme and Variable High Energy Sky", 19-23 September 2011, Cagliari (Italy), "Diffuse gamma-ray emission from the Milky Way: 8 years of INTEGRAL/SPI observation" (O)

Sergey **Tsygankov**, Astronomy Colloquium, 19.10.2011, University of Oulu, "X- and Gamma-Ray Galactic Diffuse Emission"

Mauri **Valtonen**, Multifrequency Behaviour of High Energy Cosmic Sources, Vulcan, Italy, May 2011, OJ 287 binary black hole system (I)

Mauri **Valtonen**,IBWS2011, Karlovy Vary, Czech Rep., Apr 2011, 2005-2010, Multiwavelength Campaing of OJ287 (I)

Mauri **Valtonen**,7th International Conference on Gravitation and Cosmology, 14.-19.12. 2011, Goa, India, Confirming General Relativity in the binary black hole system OJ287 (O)

Mauri **Valtonen**,May 20, 2011, ESA-ESRIN, Frascati, Italy, Confirming General Relativity to the 2nd PN order in the binary black hole system OJ287

Mauri **Valtonen**,18.2.2011, HIP, Helsinki, Radio Jet of OJ287

Mauri **Valtonen**,19.3. 2011, Tuorla, Maailmankaikkeuden suurin musta aukko

Mauri **Valtonen**,Sept 2011, Purple Mountain observatory, Nanjing, China, Open questions in the three-body problem

Research visits to foreign institutes and observing trips

Andrei **Berdyugin**, 30.10.-6.11.2011, observing at the NOT: A direct probe of extrasolar planetary atmospheres

Chris **Flynn**, Visiting Researcher, University of Sydney, Jan-May 2011

Thomas **Hackman**, Uppsala University, February 18 and December 12-14, 2011, Oleg Kochukhov and Nikolai Piskunov

Thomas **Hackman**, NORDITA, February 16-19, 2011, Axel Brandenburg

Peter **Johansson**, 11.4-17.4.2011, Max Planck fur Astrophysik, Garching, Germany

Peter **Johansson**, 16.5-20.5.2011, Institute of Astronomy, University of Cambridge, UK

Peter **Johansson**, 20.6-23.6.2011, Insititute for Astronomy, University of Edinburgh, UK

Seppo **Katajainen**, NOT: Feb 08 - Feb 11 "A Polarization Survey for Magnetic Fields in AM CVn systems", ALFOSC

Seppo **Katajainen**, ESO: 087.D-0714 "A Polarization Survey for Magnetic Fields in AM CVn systems", 11 hrs, FORS2

Seppo **Katajainen**, ESO: 089.D-0612: "Constraining the Magnetic Field Strength in Soft X-ray Intermediate Polars." 10 hrs, FORS2

Seppo **Katajainen**, ESO Users' Committee Meeting, Garching, 14.4.-15.4. 2011 (Finnish representative in Committee)

Seppo **Katajainen**, Visit to Tartu University, 20.9-23.9. Tartu - Tuorla annual meeting 2011: Remote sensing of the Universe oral: "Studies of magnetic fields in the extreme close binaries" 22.9. 2011

Jari **Kotilainen**, ESO Council and Committee of Council meetings: 1.-2.3., 7.-8.6., 5.-6.10. and 7.-8.12.2011, Garching, Germany

Jari **Kotilainen**, 22.8.2011, NOT Transient Explorer meeting, University of Copenhagen, Denmark.

Jari **Kotilainen**, 22.-25.11.2011, Padova Observatory, University of Padova, Italy.

Eija **Laurikainen**, May 2011, Laboratoire d'Astrophysique de Marseille, invited visiting professor.

Eija **Laurikainen**, 28.2.-3.3.2011, Astronomisches Rechen-Institut, Heidelberg: SMAKCED (Stellar population properties, MAsses, and Kinematics for a representative sample of Cluster Early-type Dwarfs) science meeting.

Kari **Nilsson**, University of Barcelona, Spain, 14-18 March, MAGIC Collaboration meeting

Veli-Matti **Pelkonen**, IPAC, California Institute of Technology, Pasadena, California, USA, 26.9.-24.10.2011, Peregrine McGehee & Roberta Paladini

Vilppu **Piirola**, Observing trip: NOT, October 30 - November 3, "A direct probe of extrasolar planetary atmospheres"

Mauri **Valtonen**, Purple Mountain Observatory and University of Nanjing, Sept 2011 (Prof. Ma, prof. Wang)

Mauri **Valtonen**, Tata Institute of Fundamental Research, December 2011 (Dr. Gopakumar)

Awards and recognitions

Thomas **Hackman**, Honorary member of Meridiaani

Public Relations and Media

Jari **Kotilainen**, Finnish representative of ESO Outreach Network (ESON).

FINNISH CENTRE FOR ASTRONOMY WITH ESO (FINCA)
REFEREED PUBLICATIONS IN YEAR 2011

FINCA personnel are listed in **boldface**.

[1] Abdo, A. A.; Ackermann, M.; Ajello, M.; Baldini, L.; Ballet, J.; Barbiellini, G.; Bastieri, D.; Bechtol, K.; Bellazzini, R.; Berenji, B.; et al. (including **Berduygin, A.; Nilsson, K.**). 2011: Multi-wavelength Observations of the Flaring Gamma-ray Blazar 3C 66A in 2008 October. - Astrophysical Journal, 726, 43 (14 pp).

[2] Abdo, A. A.; Ackermann, M.; Ajello, M.; Antolini, E.; Baldini, L.; Ballet, J.; Barbiellini, G.; Bastieri, D.; Bechtol, K.; Bellazzini, R.; et al. (including **Berdyugin, A.; Nilsson, K.**). 2011: The First Fermi Multifrequency Campaign on BL Lacertae: Characterizing the Low-activity State of the Eponymous Blazar. - Astrophysical Journal, 730, 101 (14 pp).

[3] Abdo, A. A.; Ackermann, M.; Ajello, M.; Baldini, L.; Ballet, J.; Barbiellini, G.; Bastieri, D.; Bechtol, K.; Bellazzini, R.; Berenji, B. et al. (including **Berdyugin, A.; Nilsson, K.**). 2011: Erratum: "Multi-wavelength Observations of the Flaring Gamma-ray Blazar 3C 66A in 2008 October" (2011, ApJ, 726, 43). - Astrophysical Journal, 731, 77 (4 pp)

[4] Abdo, A. A.; Ackermann, M.; Ajello, M.; Baldini, L.; Ballet, J.; Barbiellini, G.; Bastieri, D.; Bechtol, K.; Bellazzini, R.; Berenji, B.; et al. (including **Berdyugin, A.; Nilsson, K.**;). 2011: Fermi Large Area Telescope Observations of Markarian 421: The Missing Piece of its Spectral Energy Distribution. - Astrophysical Journal, 736, 131 (22 pp).

[5] Aghanim, N.; Arnaud, M.; Ashdown, M.; Atrio-Barandela, F.; Aumont, J.; Baccigalupi, C.; Balbi, A.; Banday, A. J.; Barreiro, R. B.; Bartlett, J. G.; et al. (including **Nevalainen, J.**;). 2011: Planck early results. XXVI. Detection with Planck and confirmation by XMM-Newton of PLCK G266.6-27.3, an exceptionally X-ray luminous and massive galaxy cluster at z ~1. - Astronomy & Astrophysics, 536, A26.

[6] Agudo, I.; Jorstad, S. G.; Marscher, A. P.; Larionov, V. M.; Gómez, J. L.; Lähteenmäki, A.; Gurwell, M.; Smith, P. S.; Wiesemeyer, H.; Thum, C. et al. (including **Nieppola, E.**). 2011: Location of γ-ray Flare Emission in the Jet of the BL Lacertae Object OJ287 More than 14 pc from the Central Engine. - Astrophysical Journal Letters, 726, L13 (6 pp).

[7] Agudo, I.; Marscher, A. P.; Jorstad, S. G.; Larionov, V. M.; Gómez, J. L.; Lähteenmäki, A.; Smith, P. S.; **Nilsson, K**.; Readhead, A. C. S.; Aller, M. F.; et al. (including **Nieppola, E.**). 2011: On the Location of the γ-Ray Outburst Emission in the BL Lacertae Object AO 0235+164 Through Observations Across the Electromagnetic Spectrum. - Astrophysical Journal Letters, 735, L10 (7 pp).

[8] Aleksić, J.; Antonelli, L. A.; Antoranz, P.; Backes, M.; Barrio, J. A.; Bastieri, D.; Becerra González, J.; Bednarek, W., **Berdyugin,A.**, Berger,K. et al. (including **Nilsson,K.**). 2011: Observations of the Blazar 3C 66A with the Magic Telescopes in Stereoscopic Mode. - Astrophysical Journal, 726, 58 (5 pp)

[9] Aleksić, J.; Antonelli, L. A.; Antoranz, P.; Backes, M.; Barrio, J. A.; Bastieri, D.; Becerra González, J.; Bednarek, W., **Berdyugin,A.**, Berger,K. et al. (including **Nilsson,K.**). 2011: MAGIC Discovery of Very High Energy Emission from the FSRQ PKS 1222+21. - Astrophysical Journal Letters, 730, L8 (6 pp).

[10] Aleksić, J.; Alvarez, E.A.; Antonelli, L. A.; Antoranz, P.; Asensio,M.; Backes, M.; Barrio, J. A.; Bastieri, D.; Becerra González, J.; Bednarek, W. et al. (including **Berdyugin,A.**, **Nilsson,K.**). 2011: A Search for Very High Energy Gamma-Ray Emission from Scorpius X-1 with the Magic Telescopes. - Astrophysical Journal Letters, 735, L5 (5 pp)

[11] Aleksić, J.; Alvarez, E.A.; Antonelli, L. A.; Antoranz, P.; Asensio,M.; Backes, M.; Barrio, J. A.; Bastieri, D.; Becerra González, J.; Bednarek, W. et al. (including **Berdyugin,A.**, **Nilsson,K.**). 2011: Observations of the Crab Pulsar between 25 and 100 GeV with the MAGIC I Telescope. - Astrophysical Journal, 742, 43 (14 pp)

[12] Aleksić, J.; Alvarez, E. A.; Antonelli, L. A.; Antoranz, P.; Asensio, M.; Backes, M.; Barrio, J. A.; Bastieri, D.; Becerra González, J.; Bednarek, W.; et al. (including **Berdyugin, A.; Nilsson, K**.). 2011: Searches for dark matter annihilation signatures in the Segue 1 satellite galaxy with the MAGIC-I telescope. - Journal of Cosmology and Astroparticle Physics, 06, 035 (28 pp).

[13] Barclay, T.; Ramsay, G.; **Hakala, P.**; Napiwotzki, R.; Nelemans, G.; Potter, S.; Todd, I. 2011: Stellar variability on time-scales of minutes: results from the first 5 yr of the Rapid Temporal Survey. - Monthly Notices of the Royal Astronomical Society, 413, 2696-2708.

[14] Berdyugina, S. V.; **Berdyugin, A. V.;** Fluri, D. M.; **Piirola, V.** 2011: Polarized Reflected Light from the Exoplanet HD189733b: First Multicolor Observations and Confirmation of Detection. - Astrophysical Journal Letters, 728, L6.

[15] Bonamente, M.; **Nevalainen, J.** 2011: X-Ray Spectroscopy of AS1101 with Chandra, XMM-Newton, and ROSAT: Bandpass Dependence of the Temperature Profile and Soft Excess Emission. - Astrophysical Journal, 738, A149.

[16] Comerón, S.; Knapen, J. H.; Sheth, K.; Regan, M. W.; Hinz, J. L.; Gil de Paz, A.; Menéndez-Delmestre, K.; Muñoz-Mateos, J.-C.; Seibert, M.; Kim, T.; et al. (including **Laurikainen, E.**). 2011: The Thick Disk in the Galaxy NGC 4244 from S4G Imaging. - Astrophysical Journal, 729, 18 (12 pp).

[17] Comerón, S.; Elmegreen, B. G.; Knapen, J. H.; Sheth, K.; Hinz, J. L.; Regan, M. W.; Gil de Paz, A.; Muñoz-Mateos, J.-C.; Menéndez-Delmestre, K.; Seibert, M. et al. (including **Laurikainen, E.**). 2011: The Unusual Vertical Mass Distribution of NGC 4013 Seen through the Spitzer Survey of Stellar Structure in Galaxies (S4G). - Astrophysical Journal Letters, 738, L17 (6 pp).

[18] Comerón, S.; Elmegreen, B. G.; Knapen, J. H.; Salo, H.; **Laurikainen, E.;** Laine, J.; Athanassoula, E.; Bosma, A.; Sheth, K.; Regan, M. W.; et al. 2011: Thick Disks of Edge-on

Galaxies Seen through the Spitzer Survey of Stellar Structure in Galaxies (S4G): Lair of Missing Baryons? - Astrophysical Journal, 741, 28 (21 pp).

[19] Copperwheat, C. M.; Marsh, T. R.; Littlefair, S. P.; Dhillon, V. S.; Ramsay, G.; Drake, A. J.; Gänsicke, B. T.; Groot, P. J.; **Hakala, P.;** Koester, D.; et al. 2011: SDSS J0926+3624: the shortest period eclipsing binary star. - Monthly Notices of the Royal Astronomical Society, 410, 1113-1129.

[20] D'Ammando, F.; Raiteri, C. M.; Villata, M.; Romano, P.; Pucella, G.; Krimm, H. A.; Covino, S.; Orienti, M.; Giovannini, G.; Vercellone, S.; et al. (including **Berdyugin, A.; Nilsson, K.**). 2011: AGILE detection of extreme γ-ray activity from the blazar PKS 1510-089 during March 2009. Multifrequency analysis. - Astronomy & Astrophysics, 529, A145 (12 pp).

[21] Elmegreen, D. M.; Elmegreen, B. G.; Yau, A.; Athanassoula, E.; Bosma, A.; Buta, R. J.; Helou, G.; Ho, L. C.; Gadotti, D. A.; Knapen, J. H. et al. (including **Laurikainen, E**). 2011: Grand Design and Flocculent Spirals in the Spitzer Survey of Stellar Structure in Galaxies (S4G). - Astrophysical Journal, 737, 32 (17 pp).

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