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CONTRIBUTED TALKS AND REVIEWS

Acceleration of Thermal and Non-thermal Seed Populations at Oblique Coronal Shocks

Markus Battarbee (University of Turku), Timo Laitinen (Jeremiah Horrocks Institute for Astrophysics and Supercomputing, University of Central Lancashire), Rami Vainio (University of Helsinki), and Heli Hietala (University of Helsinki)

Acceleration in coronal mass ejection driven shocks is currently considered the primary source of large solar energetic particle events. The dynamics of the shock fronts affect acceleration environments in a multitude of ways. We discuss analytical and statistical methods of assessing particle injection probabilities, which allows us to refine our understanding of seed population dynamics. We utilize a specifically developed Monte Carlo simulation method, where self-generated Alfv\'enic turbulence allows for repeated shock crossings and acceleration to high energies, to assess maximum energies attained. We show the effects of cross-shock potential and shock obliquity to the portion of seed particles surviving shock interactions and returning to the upstream. Thermal particles are shown to be irrelevant to the acceleration process at higher shock-normal angles.

Centaurus A - The Transition

Sarah Bird (Tuorla Observatory, University of Turku)

"The very earliest stars in giant galaxies -- the most metal-poor halo stars and globular clusters -- may have formed before the onset of hierarchical merging, within small pregalactic dwarfs that populated the largescale dark-matter potential well.

Today, these relic stars should be found in a sparse and extremely extended ``outermost-halo"" component. Finding clear traces of this component in other giant galaxies, and deconvolving it from the more obvious and metal-rich spheroid component generated later by mergers, has been extraordinarily diffcult.

Now, striking new evidence discovered in M31 and NGC 3379 suggests that the metal-poor outermost halo can be isolated at very large radii, $R > 12R_{\rm eff}$. We now have a new deep imaging study with VIMOS of the nearest giant elliptical and merger remnant, Centaurus A, to search for this extended remnant of the galaxy's earliest history, and will couple this with followup dynamical modeling.

Height-resolved energy exchange rates in the ionosphere

Lei Cai (University of Oulu), Anita Aikio, Tuomo Nygren, and Ritva Kuula

The electromagnetic energy exchange between the high-latitude ionosphere and magnetosphere can be described in terms of electromagnetic energy exchange rate q_{EM}, which is a sum of ion-neutral frictional heating rate q_J (sometimes called Joule heating) and work done on neutrals q_m. We have examined the height-resolved energy exchange rates in the ionosphere by using a one-month database obtained by EISCAT incoherent scatter radar measurements in Tromso. The CP2 scan mode of the EISCAT radar makes it possible to deduce conductivities, electric fields and neutral winds in the E region and hence estimate the different energy exchange rates. Neutral winds are the main source of Joule heating under quiet conditions, while electromagnetic energy dissipation dominates on Joule heating under active conditions. Neutral winds affect the altitude distribution of Joule heating especially at high altitudes. Electromagnetic energy dissipation enhances with increasing geomagnetic activity. The maxima takes place at 120 km. Mainly, electromagnetic energy dissipates on Joule heating. However, some EM energy goes to neutral winds at the altitudes between about 115 and 140 km under active conditions.

Re-visiting the GCS catalogue - How to use solar analogues to check metallicity and temperature scales

Juliet Datson (Tuorla Observatory, University of Turku), Chris Flynn (FINCA, University of Turku & Swinburne Universtity in Melbourne) and Laura Portinari (Tuorla Observatory, University of Turku)

In the age of large upcoming surveys, like Gaia, it is of utmost importance to set the correct scale between observations and fundamental stellar parameters (temperatue and metallicity), to properly exploit these huge databses for Galactic archaeology. For this reason it makes sense to check and confirm the scales used for different existing surveys and catalogues.

In this study we present a method to test the temperature and metallicity scale of the Geneva-Copenhagen-Survey catalogue around the solar values, and show that there might be an offset.

Constructing new population models for near-Earth asteroids

Mikael Granvik (University of Helsinki)

The best available model simultaneously describing the sizes and orbits of near-Earth objects (NEOs) was constructed using only 138 NEOs observed by the Spacewatch survey [1,2]. Although the decade-old model has worked surprisingly well it has some known shortcomings such as the inability to correctly estimate the number of large Amor asteroids and high-inclination NEOs.

We are currently working on two new NEO models that will remove the shortcomings of the old model. The first one will be a more accurate model of the entire NEO population. It will be based on >30 times more observational data provided by the Catalina Sky Survey and utilize more detailed dynamical paths from the main asteroid belt to the NEO region. The second model will concentrate on asteroids orbiting entirely within the orbit of the Earth. The observational data for this project will be provided by the Canadian Near-Earth-Object Surveillance Satellite (NEOSSat) – the first space-based NEO survey – with an anticipated launch during the second half of 2012 [4].

I will present and discuss some early results from these efforts such as the importance of including Yarkovsky thermal drag when populating the escape hatches in the main asteroid belt and the discovery of a population of near-Earth asteroids on retrograde orbits [3].

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[3] S. Greenstreet, B. Gladman, H. Ngo, M. Granvik, and S. Larsen (2012). ApJL 749, L39
[4] A. Hildebrand, E. Tedesco, R. Cardinal, B. et al. (2008), BAAS 40, 493

Assembly histories and observational properties of simulated Early-Type Galaxies

Peter Johansson (University of Helsinki)

We demonstrate that our 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. We find in general a positive correlation between the fraction of accreted stars and the final mass of our galaxies, with the most massive galaxies thus having the largest fraction of accreted stars. The two-phase formation mechanism naturally explains the observed downsizing, bimodality and size growth of the galaxy population. Very high resolution simulations show that gravitational feedback strongly suppresses late star formation in massive galaxies contributing to the observed galaxy color bimodality. However, additional heating sources probably in the form of AGN and SNI feedback are also required to prevent late gas inflows and associated residual star formation in the more massive galaxies.

Consistent with their assembly histories we find that the dark matter fractions within the stellar half-mass radii continuously increase towards lower redshift from about $f_{\rm DM} \sim 0.05$ at $z \sim 3$ to $f_{\rm DM} \sim 0.1$-0.3 at $z = 0$. In addition, the logarithmic slope of the total density profile is nearly isothermal at the present-day $\gamma' \sim 1.9$ - 2.2 also in good agreement with recent lensing observations. Finally, we find a correlation between the photometric and kinematic properties of the galaxies and their formation history. The more massive galaxies with a larger accreted component are typically better fitted by single component Sersic functions and are more slowly rotating, whereas the lower mass galaxies with a larger in situ fraction are typically fast-rotators best fitted by a two-component (disk+bulge) light profile.

Observations and modelling of Galactic star forming clouds

Mika Juvela (University of Helsinki) on behalf of the project Galactic Cold Cores

In the past decade there has been an entire fleet of space instruments operating at infrared and radio wavelengths. These are producing new information on the evolution and physics of interstellar clouds and are providing insights to the star formation process within our Galaxy. I will describe studies carried out within the Herschel satellite key programme Galactic Cold Cores. I will present some recent observational results and discuss the modelling of dust emission from star forming clouds.

Core-collapse supernovae in dusty environments

Erkki Kankare (Tuorla Observatory, University of Turku), Seppo Mattila (Tuorla Observatory, University of Turku), Stuart Ryder (Australian Astronomical Observatory)

Core-collapse supernovae (CCSNe) provide an independent tool for tracing star formation directly and independently due to the short lifetimes of their massive ($M \geq 8M_{\odot}$) progenitors. This is especially interesting in the case of luminous ($L_{\rm IR} > 10^{11}$ L$_{\odot}$) and ultraluminous ($L_{\rm IR} > 10^{12}$ $L_{\odot}$) infrared (IR) galaxies (LIRGs and ULIRGs, respectively) with high star formation (SF) rates, which also become the dominant source of SF at high redshift ($z \geq 0.7$). These galaxies are also heavily obscured by dust and extinction corrections are one of the most uncertain biasing factor in studies of their SN rate. However, SNe can be used to map extinction distributions in their host galaxies. Unfortunately the number of SNe discovered using optical/near-IR wavelengths in highly crowded and obscured U/LIRGs has been quite modest. Therefore, high spatial resolution searches using near-IR are required and we have conducted a four year pilot study of searching CCSNe in a sample of eight LIRGs using the adaptive optics system ALTAIR/NIRI with a laser guide star on the Gemini-North Telescope. Lastly the improved SN statistics will help answering the question if the CCSN population in LIRGs is similar to that of normal spiral galaxies.

Polarization Survey For Bright AM CVn Systems

Seppo Katajainen [1], Pasi Hakala [2], Thomas Barclay [3], Gavin Ramsay [4], Stefan Bagnulo [4], Mark Cropper [5], Colin Folsom [4], Sarah Bird [1], Auni Somero [1]

[1] Tuorla Observatory, University of Turku, [2] Finnish Centre for Astronomy with ESO,
[3] NASA Ames Research Center, [4] Armagh Observatory, [5] Mullard Space Science Laboratory

It is estimated that one in four Cataclysmic variables have strong magnetic fields, but it is not known whether this extends to AM CVn type interacting binary stars. These are ultracompact binaries with orbital periods of less than 70 minutes. We therefore have studied bright AM CVn systems which are bright enough to guarantee a high Signal/Noise ratio in polarimetry. We have searched for evidence of strong magnetic fields using polarization. A detection of any AM CVn system emitting polarized light has important consequences for binary evolution theory and allow us to place constraints on the dominant formation channel of AM CVn systems, which is a crucial ingredient in understanding CV evolution in general.

Modelling the X-ray spectra of black hole binaries: The black hole spin controversy

Mari Kolehmainen (Durham University)

Black hole spins are currently very controversial, with the results from the relativistically broadened iron line typically giving higher values of spin than those found from fitting disc continuum models. The Galactic black hole binary GX 339-4 is the archetypal source for this, with multiple claims of very high spin from the iron line.

I re-analyse all the XMM-Newton burst mode and timing mode spectra of this source and show that the iron line shape inferred from these fits is highly dependent on the chosen continuum model, regardless of the mass accretion rate. The disc emission seen in the disc dominated spectra is clearly broader than the widely used simple models, so fitting such models to the continuum forces a broad residual into the data. Broader disc continuum models give a much narrower derived line profile, consistent with the lower spin value from disc spectral fitting.

The multiwavelength spectral and timing properties of a major radio flare episode in Cygnus X-3

Karri I.I. Koljonen (Aalto University Metsähovi Radio Observatory), D.C. Hannikainen (Aalto University/MRO/FIT), M.L. McCollough (CfA/SAO/CXC), G. Pooley (MRAO), S. Trushkin (SAO/RAS), M. Tavani (INAF)

Cygnus X-3 exhibits major radio flares/jet ejection events like no other microquasar with radio flux densities up to 20 Jy. During these major flares Cygnus X-3 displays a variety of phenomena across the electromagnetic spectrum, including unique temporal properties such as gamma-ray flares observed before the onset of major radio flares when the source is in a special radio/X-ray state and quasi-periodic oscillations observed during the major flare decay. Here we present our attempt to form a unified picture of the nature of these jet ejection events through studies of the spectral and timing X-ray properties during major flares and modeling the spectral energy distribution from the radio through to the X-rays/gamma-rays.

Galaxy populations in rich and poor environments

Heidi Lietzen (Tuorla Observatory, University of Turku)

Several studies have shown that properties of galaxies depend on their environment. Galaxies in dense environments are more often elliptical, have lower star-formation rate, are more luminous, and are more likely to host a radio-loud active nucleus than galaxies in low-density environments. It has not yet been known if these properties of galaxies are fully determined by the local, group-scale environment or if the larger scales also affect their evolution. In the latest study of our research group, we have analysed statistical properties of galaxies on two different scales of environment: the group scale and the supercluster scale. We have found that galaxies in groups of equal richness are more often star-forming in void regions than in superclusters. The group richness required to quench star-formation in the majority of galaxies is higher in the void regions. This means that galaxy populations depend on the large-scale environment independently of the group scale. Our result may be interpreted as an evidence for an assembly bias in groups: the evolution of galaxies is enhanced or suppressed by their large-scale environment. In other words, galaxies in voids developed later than galaxies in superclusters.

The Planck mission and early results

Anne Lähteenmäki (Aalto University Metsähovi Radio Observatory)

European Space Agency ESA's Planck satellite was launched in May 2009, and it has recently completed its nominal and extended all sky surveys. Planck measured, with an excellent resolution at several high radio frequencies, the cosmic microwave background (CMB) anisotropies of the whole sky. At the same time all radio sources in the foreground, such as active galactic nuclei (AGN), galaxy clusters, and Galactic sources, were measured, too. In this presentation I review the Planck mission and the results obtained so far.

Core supernovae missed by optical surveys

Seppo Mattila (Tuorla Observatory), T. Dahlen (STSci), E. Kankare (Tuorla Observatory)

We have estimated the fraction of core-collapse supernovae that remain undetected by optical supernova searches due to obscuration by large amounts of dust in their host galaxies. This effect is especially important in luminous and ultraluminous infrared galaxies, which are locally rare but dominate the star formation at redshifts of z ~ 1–2. It is therefore crucial to take into account the effects of obscuration by dust when determining supernova rates at high redshift and when predicting the number of core-collapse supernovae detectable by the future high-z surveys such as LSST, JWST, and EUCLID.

Young pulsars as ultra-luminous X-ray sources

Aleksei Medvedev (University of Oulu)

The nature of the ultraluminous X-ray sources (ULXs) has been a matter of debate during last decade. Most popular hypothesis associate them with the stellar-mass black holes accreting at super-Eddington rates or with the intermediate-mass black holes. Some bright X-ray sources could also be young supernovae (SNe) remnants, young rotation-powered pulsars, or pulsar wind nebulae. The aim of the present paper is to investigate a possible contribution of the rotation-powered pulsars and pulsar wind nebulae to the ULX population in view of the recent results on the dependence of their X-ray efficiency on characteristic age. Here we analyse the observed X-ray luminosity distribution of core-collapse SNe together with the distribution of the upper limits.We construct a Monte Carlo model for the X-ray luminosity function and show that pulsars with the mean birth period of ≈ 20 ms satisfy the observed luminosity distribution of the core-collapse Sne. We also demonstrate that young pulsars with luminosities $L_X \geq 10^{39}$ erg s^{-1} may exist. We estimate the contribution of the rotation-powered pulsars to the whole ULX population at the 1– 0 per cent level.

Relativistic kinetic equation for Compton scattering of polarized radiation in strong magnetic field

Alexander Mushtukov (University of Oulu, Pulkovo Observatory of Russian Academy of Sciences), Dmitrij Nagirner (Saint-Petersburg State University), Juri Poutanen (University of Oulu)

We derive the relativistic kinetic equation for Compton scattering of polarized radiation in strong magnetic field using the Bogolyubov method. The induced scattering and the Pauli exclusion principle are taken into account. The electron polarization is also considered in the general form of the kinetic equation. The special forms of the equation for the cases of the non-polarized electrons, the rarefied electron gas and the two polarization mode description of radiation are found. The derived equations are valid for any photon and electron energies and the magnetic field strength below about 10^{16} G. These equations provide the basis for formulation of the equation for polarized radiation transport in atmospheres and magnetospheres of strongly magnetized neutron stars.

Star formation in the cometary globule CG1

Minja Mäkelä (University of Helsinki)

Cometary Globule 1 is the archetype of classic cometary globules located in the Gum Nebula at a distance of 300pc. In its head is located NX Puppis, a star already formed in the cloud, and a young stellar object (YSO) which we have discovered earlier (Haikala, Mäkelä, Väisänen, 2010, A&A, 522: A106). Here we present nearinfrared (NIR) obervations made with SOFI/NTT along with additional archive data from WISE and Spitzer. We have mapped the visual extinction in CG1 and compiled a spectral energy distribution (SED) for the YSO. A possible outflow candidate for the YSO is found. Using these data we attempt to determine the formation mechanism of CG1.

X-ray and optical confirmation of the intermediate polar status of the enigmatic cataclysmic variable FS Aurigae

Vitaly Neustroev (University of Oulu)

FS Aur is famous for a variety of uncommon and puzzling periodic photometric and spectroscopic variabilities. It was previously proposed that the precession of a fast-rotating magnetically accreting white dwarf can successfully explain these phenomena. Our new optical multicolor observations of FS Aur revealed, for the first time in photometric data, the variability with the presumed precession period of the WD. This is best seen in the (B-I) color index and reflects spectral energy distribution variability. We also find that the modulation with the precession period is evident in X-ray data. There appears to be a clear signature of the energy dependence of this modulation, as seen in the hardness ratio curves. We show that the observed properties of FS Aur closely resemble those of other IPs, thus confirming this cataclysmic variable as an intermediate polar.

The physical and chemical state of cold dust cores mapped with Herschel

Anna Parikka (University of Helsinki)

A number of sources that are likely representing an early pre-stellar phase of star formation were detected in the all-sky sub-millimetre survey of the Planck satellite and have now been also mapped at higher resolution by Herschel using wavelengths 100–500 μm. In this study three of these clouds have been selected for further study. The sources were selected on the basis of low dust temperatures ($T_{\mathrm{dust}} \sim$ 10 K), which suggests that the sources have dense cores that do not yet have significant internal heating.

Observations of the selected clouds were made in the Onsala Space observatory and the selected fields were mapped in ^{13}CO and strips across these regions were also made in C^{18}O. The aim of the observations and my study is to determine the physical parameters of the gas component, examine the stability of the cores and measure molecular depletion. In my presentation I will present the results of the analysis of these observations.

Simulations of gamma-ray burst afterglow spectra and light curves

Tuulia Pennanen (University of Oulu), Indrek Vurm (Hebrew University of Jerusalem), Juri Poutanen (University of Oulu)

A gamma-ray burst (GRB) afterglow is the result of the interaction between the relativistic jet launched by the GRB progenitor and the interstellar medium. The collision between the jet and the external medium initiates a forward and a reverse shock wave, where electrons are accelerated to relativistic energies before emitting the observed afterglow radiation.

We have developed a numerical code that models the afterglow emission by the relativistic electrons. The code calculates time-evolving electron and photon distributions by solving the kinetic equations for both particle species within the emission region. The main radiative processes shaping the distributions are synchrotron radiation and inverse Compton scattering. In addition to synchrotron cooling of the electrons, the code takes into account synchrotron self-absorption, which modifies the particle distributions at low energies. The code also deals with additional processes, such as electron-positron pair production.

An earlier version of the code has been extensively tested by e.g. modeling prompt GRB emission. The code has since been modified and is now applicable to afterglows, as it accounts for the hydrodynamic evolution of the emitting shell. Our code is the first one to solve the coupled integro-differential kinetic equations without any energy limitations for the electrons and photons. We present the spectra and light curves that were obtained in our simulations and compare them to solutions previously presented in the literature.

Highlights from the Fermi Gamma-Ray Space Telescope

Juri Poutanen (University of Oulu)

Fermi Gamma-Ray Space Telescope launched in 2008 has two major instruments on board: GBM-Gamma-ray Burst Monitor - working in 10 keV–30 MeV range, and LAT - Large Area Telescope - operating in the 100 MeV–300 GeV energy range. During three and a half years of its operation Fermi has produced a number of exciting discoveries: it detected gamma-ray bursts in the GeV domain, constructed detailed energy distribution of blazars that show interesting spectral features, observed dozens of pulsars, and measured the spectrum of the cosmic-ray electrons and positrons. I will review the most interesting from my point of view discoveries.

Looking through the dust in luminous infrared galaxies.

Cristina Romero-Canizales (Tuorla Observatory, University of Turku), Antxon Alberdi (IAA-CSIC), Miguel A. Perez-Torres (IAA-CSIC), Seppo Mattila (Tuorla Observatory, University of Turku) and Erkki Kankare (Tuorla Observatory, University of Turku).

Vigorous massive star formation and/or the presence of an AGN are the main mechanisms thought to be responsible of the dust heating in luminous ($L_{IR} > 10^{11}$ $L_{\odot}$) and ultra luminous ($L_{IR} > 10^{12}$ $L_{\odot}$) infrared galaxies. These mechanisms are however hidden in the highly obscured and dense nuclear and circumnuclear regions of (U)LIRGs, and high angular resolution, high sensitivity radio observations represent an excellent tool to detect them.

We present here the results of our radio observations towards Arp299-A and IC883. These LIRGs, having different infrared luminosities and being at different merger stages, are part of the very small group of galaxies where the starburst-AGN connection can be studied in detail.

Needles in a haystack: globular clusters in Maffei 1

Ricardo Salinas (FINCA, University of Turku)

At a distance of only ~2.8 Mpc, Maffei 1 is our closest elliptical galaxy. This advantage has been overshadowed by its difficult relative position in the sky; at a Galactic latitude of only $b = 0.5$, the extinction in optical bands can be as high as five magnitudes. The high extinction, together with high contamination from the Galactic plane has made the measurement of even its most basic parameters a difficult and uncertain task. For example, studies of its globular cluster system (GCS) have produced only a handful of globular cluster candidates, whereas for its luminosity, the size of its GCS should be comparable to the one of Cen A, hosting ~1300 GCs. We present the first results of wide-field study of the Maffei 1 GCS conducted using Subaru/SuprimeCam. Based on the slightly non-stellar profiles of the GCs at this distance, we detect a sizeable population across the entire SuprimeCam field of view.

A comparison of turbulent closure models with direct numerical simulations of convection

Jan Snellman (University of Helsinki), Petri Käpylä (University of Helsinki), Maarit Mantere (University of Helsinki)

Stellar evolution models require a simple analytical description of turbulent heat flux due to convection. Schemes, such as the mixing length model, are widely used but lack solid theoretical foundation. A more tenable approach is to derive the turbulent quantities from Navier-Stokes equations with the help of a suitable closure model. These models involve replacing problematic terms with simpler ones using physical assumptions, which need to be justified by either experimental data or direct numerical simulations.

Here we compare a simple analytical closure model (CM) of turbulent convection with three-dimensional direct numerical simulations (DNS). In the CM the higher than second order terms in the fluctuations are modeled by physically motivated relaxation and isotropization terms. To perform this comparison, mean velocities and temperature, Reynolds stress, heat fluxes, and the temperature variance are computed from the CM and DNS as functions of rotation and Rayleigh number describing the efficiency of convection. The free parameters appearing in the closure models are then calibrated using simulation data. Although we find a qualitative agreement between closure and the simulations in many aspects, the presence of solid boundaries in our numerical models produces effects not taken into account in the closure under study.

RS Ophiuchi - an enigmatic accreting system

Auni Somero (Tuorla observatory, University of Turku), Pasi Hakala (FINCA, University of Turku), Graham Wynn (University of Leicester)

RS Ophiuchi is a symbiotic variable star and a recurrent nova. It consists of a white dwarf accreting from an M giant companion. It is unclear whether the accretion process occurs via Roche lobe overflow or stellar wind capture. Particularly interesting is the possibility that it could represent a progenitor system for type Ia supernova. A spectroscopic survey over the 455 day period of RS Oph has been conducted on the Nordic Optical Telescope.

This talk will address the intricacies of the observations and a peek into the future of the study of this quizzical and exciting system.

Origin of gamma radiation in active galactic nuclei

Esko Valtaoja [1], Jonathan Leon-Tavares [2], Anne Lähteenmäki [2], Elina Nieppola [2], Joni Tammi [2], Merja Tornikoski [2]

[1] Tuorla Observatory, University of Turku
[2] Aalto University Metsähovi Radio Observatory

The origin of gamma-ray radiation from active galactic nuclei has been a disputed topic ever since the first Compton/EGRET detections over twenty years ago. A "near" origin, close to the black hole and the accretion disk, has mostly been favored by theoreticians, while observers have pointed out strong evidence indicating a "distant" origin, connected to the radio core and shocks along the relativistic jet. We discuss recent data from Fermi, Planck and multifrequency campaigns, concluding that no single mechanism or emission site seems to be sufficient to explain all the observations.

Hot accretion flow in X-ray binaries: spectral and timing evidence

Alexandra Veledina (University of Oulu, Finland), Juri Poutanen (University of Oulu, Finland), Indrek Vurm (Racah Institute of Physics, Israel)

The black hole X-ray binaries were intensively studied over the last decades, however many aspects of their accretion-ejection processes remain uncovered. Among those, the accretion geometry in the very vicinity of the central object is one of the most exciting. In standard picture the geometrically thin optically thick disc extends very close to black hole at high mass accretion rates (in the soft state). At lower accretion rates (in the hard state) it is likely truncated, giving rise to geometrically thick optically thin flow. We demonstrate that presence of this hot flow is reflected in characteristic spectral and timing features. I will show how to use this information to determine accretion flow parameters.

Radar Observable Simulations: Interpretation in terms of Near-surface Physical Properties of Asteroids

Anne Virkki (University of Helsinki)

A basic strategy for observing a small solar-system object using radar is to measure the distribution of echo power in time delay and Doppler frequency for a circularly polarized transmitted wave. Using radar typical transmitter frequencies are 2380 MHz or 8495 MHz. The circular-polarization ratio μ is the ratio of the echo power in the same circular-polarization state (SC) to that in the opposite circular-polarization state (OC) to the transmitted wave. The ratio μ is often the most important physical observable with the radar technique, as it is considered to provide the best indications for wavelength-scale complexity of the surface. There also is some evidence of the effect of the refractive index (Mishchenko and Hovenier (1995) Optics Letters 20, 1356), but we have not found any similar, systematic studies that been carried out.

We model electromagnetic scattering from closely-packed random aggregates of spheres imitating the structure of an asteroid's regolith. Both scattering and absorption of the electromagnetic wave are treated. The Multiple-Sphere T-Matrix Method computer software (Mackowski and Mishchenko 2011 JQSRT 112, 1282) is utilized to study how different parameters affect the circular-polarization ratio, i.e., the size distribution ,size parameters and refractive indices of the spherical particles forming the different aggregates. Our ultimate goal is to see if the computed circular-polarization ratios can be linked to the observed data of asteroids detected with radar and hence, to explain the variations in the data.

The results of the simulations show a striking interference structure for the backscattering circular-polarization ratio as a function of the monomer size parameter (x) and the relative refractive index (m) of the medium for monodisperse aggregates. The size distribution has an effect: the in phase constructive interference by monodisperse spheres may cause μ to increase up to eight, whereas in the more realistic case of the polydisperse aggregates the interference is less in phase, causing the values of μ to moderate toward higher values of m and x. Absorption may even enhance the SC/OC ratio as long as Im(m) is about 0.05–0.1. Toward zero, the difference to no-absorption case is decreasive, and above Im(m) = 0.1, incident radiation is increasingly absorbed before any multiple scattered radiation returns. Backscattering intensity (directly proportional to the radar albedo) seems to be inversely proportional to μ at high values of x and m. At small values both intensity and μ approach zero as the backscattering decreases. Averaged over multiple polydisperse, absorbing aggregates, the simulations approach simulating realistic regolith, and hence, indicate reasons for the variations in the observed data.

High-resolution ammonia mapping of the protostellar core Cha-MMS1

Miikka Väisälä (University of Helsinki)

The aim of this study is to investigate the internal structure and kinematics of the nearby protostellar core Cha-MMS1. Cha-MMS1 has been mapped in the NH$_3(1,1)$ line and the 1.2 cm continuum using the Australia Telescope Compact Array, ATCA. The angular resolution of these observations is 6", and the velocity resolution is 50 m/s. An elongated condensation with a maximum length of 9000 AU ($1\arcmin$) is seen in ammonia. The ammonia lines are very narrow and trace cool gas. The condensation has a steep velocity gradient directed perpendicularly to the axis of elongation. The gradient can be interpreted as rotation around this axis. A string of weak 1.2 cm continuum sources is found close to the suggested axis of rotation. We suggest the observed ammonia distribution can be explained by a rotating, dense outflow. As the central source represents the protostellar Class 0 or even an earlier stage of evolution, the outflow can have been launched from the first hydrostatic core.

Super star clusters in interacting luminous IR galaxies

Petri Väisänen (The South African Astronomical Observatory / SALT)

I will describe an on-going survey of luminous IR galaxies using NIR adaptive optics and spectroscopic follow-up. A variety of phenomena can be studied in detail, such as nuclear and circumnuclear starbursts,massive super star clusters, sites of strong off-nuclear SF, and very obscured SNe. All of these are used to define the sequence of triggering and propagation of star-formation and interplay with nuclear activity in the lives of gas rich galaxy interactions and mergers. In this talk I will concentrate on super star clusters, the possible progenitors of Globular Clusters, their distribution and mass and luminosity functions.

POSTERS

Dark matter and structure formation in the universe

Jussi Aaltonen (University of Helsinki)

A brief overview of the vital role of dark matter in explaining the formation of the earliest structures in the universe.

Dust Astronomy, Comets and The COSIMA Project

Khawaja Ashraf (Tuorla observatory,University of Turku), Harry Lehto, (Tuorla observatory, Univerity Of Turku), Johan Silén, (Finnish meteorological institute), Tuomas Lönnberg (Department of Chemistry, University of Turku), Kirsi Lehto,(University of Turku)

Dust astronomy provides useful methods for measuring the surface composition of comets and asteroids, directly. Interplanetary dust particles from comets, asteroids and, the dust grains from star forming regions are the targets of dust telescopes [3]. Comets are considered as the least processed leftover of the solar nebula. Exploring comets can unlock the mysterious nature and the origin of the cometary material. Ground based observations reveal limited information about the detailed composition of comets. Nearly everything we know about the shapes and the other details of comets come from previous cometary missions. The Rosetta mission of the European Space Agency was launched in 2004 towards the comet 67P/Churyumov-Gerasimenko. It will rendez-vous the comet in 2014 and remains in its proximity for the two years. Twenty-two [1] experiments are onboard Rosetta spacecraft consisting of a lander and an orbiter. The Cometary Secondary Ion Mass Analyzer (COSIMA) is one of instruments onboard Rosetta orbiter. It is a high resolution time-of-flight (TOF) mass spectrometer with a resolution of $m/\Delta(m)$ ~2000 at m=100 [2]. COSIMA will collect cometary dust particles in situ at low speed for characterizing the elemental, molecular, mineralogical and isotopic composition of dust particles in the coma of comet 67P/CG. Understanding the details of the chemical composition of dust at comets will address questions such as what is the role of comets in delivering the raw materials for the onset of life on Earth and at what state and complexity this raw material is.

[1] R. Schulz et al, 2009, Solar System Research, 43, 343
[2] J. Kissel et al, 2007, Space Sci. Rev., 128, 823
[3] E. Grun et al, 2009, Planetary Science Decadal Study., 1, 25

The Effect of Thermal Instability on Dynamo Action in the Interstellar Medium

Elizabeth Cole (University of Helsinki)

Numerous studies have investigated the role of thermal instability in regulating the phase transition between the cold cloudy and warm diffuse medium of the interstellar medium. Considerable interest has also been devoted in investigating the properties of turbulence in thermally unstable flows, special emphasis on molecular clouds and the possibility of star formation. In this study, we investigate another setting in which this instability may be important, namely its effect on dynamo action in interstellar flows. The setup we consider is a three dimensional periodic cube of gas with an initially weak magnetic field, subject to heating and cooling, the properties of which are such that thermal instability is provoked at certain temperature regime. Dynamo action is established through external forcing on the flow field. By comparing the results with a cooling function with exactly the same net effect but no thermally unstable regime, we find the following. The critical Reynolds number for the onset of the large-scale dynamo was observed to roughly double between the thermally stable versus unstable runs, the conclusion being that the thermal instability makes large-scale dynamo action more difficult.

Narrow-Line Seyfert 1 galaxies - a multi-frequency study

Emilia Järvelä (Aalto University Metsähovi Radio Observatory, University of Helsinki)

Narrow-Line Seyfert 1 (NLS1) galaxies are intriguing young active galactic nuclei (AGN) characterized by narrow forbidden and permitted emission lines. According to studies they have low-mass black holes and are hosted mostly in spiral galaxies. NLS1s aroused much interest when Fermi Gamma-ray Space Telescope detected high-energy \gamma rays from a few NSL1s and thus confirmed the presence of a relativistic jet in those sources. It was formerly thought that only AGN living in elliptical galaxies and with super-massive black holes can host a jet. Studying NLS1s can help us understand the underlying processes of AGN activity and evolution. For our study we selected 292 NLS1s and divided them into two samples - radio loud and radio quiet - by radio loudness. For the samples we computed correlations between various wavebands (radio, infrared, optical and X-rays). The aim of the reseach was to determine how different wavebands are connected and in that way get more insight into how and where different kinds of radiation are produced in the RQ/RL NLS1s. In the RQ sample we found very strong correlation between optical and infrared whereas for the RL sample the correlation between radio and optical was the most significant.

The Timing of the Fluvial Systems in the Eastern Hellas Region, Mars: A Case Study of Dao Vallis

Soile Kukkonen (University of Oulu), J. Korteniemi and V.-P. Kostama

Impact crater statistics is a useful way to estimate relative and absolute ages on a planetary body without any returned samples. The concept of the age determinations is to measure the number of craters accumulated on a given surface unit, i.e. the crater size-frequency distribution, and fit a known crater production function to it. When the crater frequencies for certain crater sizes are compared with a chronology function, it is possible to obtain an absolute model age of the studied surface.

In this study, we use the impact crater method to date one of the Martian outflow canyons, Dao Vallis. Dao Vallis is one of the four large canyons located on the eastern rim region of the Hellas Impact Basin. The canyon cuts the surrounding Late Noachian--Early Amazonian (3-4 Gyr) age sedimentary, volcanic and mixed materials mostly postdating their emplacement. Dao begins as a full size structure in a broad, flat-floored and closed depression and follows the regional slope toward Hellas Planitia. The general morphology and volume of the head depression suggest that the canyon formed due to a release of a large mass of water. The current surface of the canyon floor has been modified by later geologic processes.

The model ages of the surface units are calculated from ConTeXt camera (CTX) images (6 m/pix) and High Resolution Imaging Science Experiment (HiRISE) datasets (0.25 – 0.5 m/pix). Our aim is to identify what kind of units Dao Vallis consists of and how the units relate to each other and the canyon formation. We also estimate the usability of the crater counting method in the cases where the studied surfaces are expected to be small and young.

The work is part of an ongoing project looking into the eastern Hellas fluvial systems, where the goal is to form a detailed picture of the drainage system evolution and to relate them to changes in the Martian climate.

Spot activity of rapidly rotating late-type stars

Marjaana Lindborg (University of Helsinki), Heidi Korhonen (Finnish Centre for Astronomy with ESO), Thomas Hackman (University of Helsinki), Maarit Mantere (University of Helsinki), Ilya Ilyin (Astrophysikalisches Institut Potsdam), Oleg Kochukhov (Uppsala University), Nikolai Piskunov (Uppsala University)

Rapidly rotating late-type stars can be seen as analogues to the young Sun. Due to the rapid rotation, they exhibit strong magnetic activity. The star spots of these objects are much larger than the sunspots, often concentrated near the poles instead of the equatorial regions and follow a non-axisymmetric distribution.

Doppler imaging is a very commonly used tool for investigating these star spots and temperature spots on the stellar surfaces. Cool spots induce a bump in

observed spectral line profiles, which can be inverted to temperature maps of the stellar surfaces. We have observed several key targets of the Northern hemisphere at the Nordic Optical Telescope located in La Palma, and here we will present studies of the K0 giant DI Pisces and RS CVn star II Pegasi. One of the main goals of our research project is to gain understanding of the magnetic activity of late-type stars by combining observational programs and direct numerical simulations. This knowedge can be used e.g. to improve models of the solar activity, from the young to the present-day Sun.

Development of tracking system for satellite ground station

Winter, E.; Dahl, J.; Nordling, Kalle.; Praks, J.;Kiviluoma, P.; Kuosmanen, P.

A satellite, in this context is a man-made object that orbits around the earth. At this very moment hundreds of satellites in all sizes are orbiting the earth, handling all kinds of communication e.g. earth observation, navigation and weather information. A CubeSat is a miniature satellite standard of about 1 litre per unit. Aalto-1 is the first Finnish satellite and it is consisting of three units. The measurements of the whole satellite are 340x100x100 mm.

One of the main payloads is a spectrometer which takes pictures in different wave lengths. Because of the large data-packages sent from the spectrometer the satellite needs a high speed wireless connection. That is why the CubeSat uses S-bandwidth that ranges from 2 to 4 GHz which is uncommon in small size satellites. To handle the communication with a satellite orbiting the earth a ground station of sufficient size is needed. The ground station consists of an antenna connected to a computer controlled rotating actuator attached to a mast. This allows the user to aim the antenna at the satellite and track it when it passes over until it is out of sight.

In this paper we present how to design, build and calibrate a low-cost and simple ground station for S-band communication in educational purpose. The design had to be light weight but strong enough to hold the wind load. To make the ground station more versatile the mast was made compatible with different kind of antennas. The goal was to achieve an aiming accuracy better than one degree. Different kinds of calibration methods were also investigated to see which method would provide the most accurate calibration. To test the accuracy of the ground station contact is made with different satellites and one can then measure the signal and see if the pointing accuracy is lost over time. "Influence of accretion flow on the cooling of neutron star atmospheres after X-ray bursts: impact on mass and radius measurements

Influence of accretion flow on the cooling of neutron star atmospheres after X-ray bursts: impact on mass and radius measurements

Joonas Nättilä (University of Oulu), Jari J.E. Kajava (University of Oulu), Outi-Marja Latvala (University of Oulu), Valery Suleimanov (Eberhard Karls University), Duncan Galloway (Monash University) and Juri Poutanen (University of Oulu)

Thermonuclear (type-I) X-ray bursts from low mass X-ray binaries (LMXB) can be used to study properties neutron stars (NS). Some bursts can be so energetic that they cause the whole photosphere of the NS to expand. These photospheric radius expansion bursts (PRE-bursts) can be used to measure NS masses and radii simultaneously. This can be achieved by computing accurate NS atmosphere models, and then applying these model predictions to observed (time-resolved) X-ray spectra when the atmosphere starts cooling after the burst. The mass and radius measurements in turn gives us a way to differentiate between the numerous models that describe the composition of NSs. By determining the correct NS model, we can infer what happens to matter when it is compressed beyond normal nuclear densities in the interiors of NSs.

A common problem encountered using this method is that different bursts from a given system can yield completely different mass and radius measurements. This fact casts a doubt on the robustness of the entire method. To reveal the causes of this behavior, we study the LMXB 4U 1608-52 that exhibits PRE-bursts at various accretion rates (and spectral states).

We find a clear difference between the PRE-burst properties at low accretion rates (hard spectral state) and high accretion rates (soft spectral state). The atmospheric cooling of PRE-bursts at low accretion rates (hard state) show behavior which is consistent with the theoretical predictions of the neutron star atmosphere models. On the contrary, PRE-bursts occurring at high accretion rates (soft state) show behavior which is inconsistent with the models. This suggests that when the source is in the soft state, the accretion flow strongly distorts the emitted spectra when the atmosphere is cooling. We therefore argue that only hard state PRE-bursts can be used with this method to measure NS masses and radii. Using this information we use the hard state PRE-bursts to constrain the mass and radius of the NS in 4U 1608-52. Our constraints are completely different from the values reported in the literature where soft state PRE-bursts have been used.

Is Delta Scorpii actually a triple system?

Alexey Pasechnik (University of Turku) Seppo Mikkola (Tuorla Observatory), Anatoly Miroshnichenko (University of North Carolina at Greensboro)

Delta Scorpii has long been known as a spectroscopic binary with a period of 11.8 years, which orbit has a high eccentricity. Observation of the last two (2000, 2011) periapsis playthroughs reveal differences of the radial velocities curves. This difference could be explained by the presence of the third component. In this work we analyse the possible configurations of a triple system, that could lead to the observed radial velocities curves differences. Shown that most likely is the presence of a third external component with mass below 1.5 Msol on the orbit with a period from 100 to 200 years.

Precursor flares in OJ 287

Pauli Pihajoki (University of Turku), Mauri Valtonen (University of Helsinki)

We have studied three most recent precursor flares in the light curve of the blazar OJ 287. A precessing binary black hole model for the OJ 287 is used to explain the nature of these precursor flares. Flare timings from the historical light curve are compared with a model combining an analytical accretion disk model and a 3rd order accurate Post—Newtonian computation of the binary orbit. We find that the precursor flares coincide with the secondary black hole descending towards the accretion disk of the primary black hole from the observed side, with a mean z-component of approximately $z_c = 4231$ AU.

An alert system for the Geodetic VLBI source database

Elizaveta Rastorgueva-Foi (Aalto University Metsähovi Radio Observatory), Nataliya Zubko (Finnish Geodetic Institute)

Geodesy provides terrestrial and celestial reference frames that are nowadays used virtually everywhere. Geodetic VLBI (GeoVLBI) is one of the techniques that are used to define the terrestrial reference frame and Earth orientation parameters, however, only GeoVLBI observations ensure the celestial reference frame. GeoVLBI is based on precise measurements of signal arrival time to telescopes and thereby determination of time delays. Knowing the time delays, the various parameters, for example, coordinates of telescopes can be estimated. GeoVLBI differ from the astrophysical VLBI mainly by the assumption that the observed radio sources are point-like, since any extended structure around VLBI core leads to errors of the station position determination. GeoVLBI also imposes a constraint on the flux level of reference active galactic nuclei (AGN): correlated flux at the longest baseline should be more than 1 Jy at 2 and 8 GHz, since sources are observed for short time. International VLBI Service for Geodesy and Astrometry (IVS) provides a database of 728 compact radio sources. During each GeoVLBI session, a subset of sources from this database is observed.

AGN are highly variable sources. Their flux and structure change fast, and, in most cases, unpredictably. A drop of the flux of a source or emergence of a new bright jet component from the core makes the source unsuitable for the GeoVLBI observations for some time period. It is important to exclude the unsuitable sources from the observations beforehand and replace them with more stable ones.

Astrophysics works on revealing the physical mechanisms behind AGN-related phenomena, and possibility to predict AGN behavior. Astrophysical studies provide an enormous amount of monitoring data, that can be collected into a consistent system, and serve as a ground for predicting the change of activity state of AGN included in the IVS database.

We announce a start of an effort to create a semi-automatic "alert system" for the IVS AGN database. Astrophysical data on AGN are gathered semi-manually from various sources (publications, flux/VLBI monitorings, etc) for each IVS AGN. The influence of source's behavior on GeoVLBI solution is studied, that allows to determine border conditions for a radio source, within which it is still suitable for GeoVLBI observations. These data are semi-automatically combined into a consistent system that provides timely activity status information on the AGN from the IVS database. When completed, this system will be able to issue an automatic alert in case some source from the database changed its activity state and become unsuitable for GeoVLBI observations.

We are now at the first stage of the development of the project. Metsähovi AGN monitoring at 37 and 22 GHz includes 173 sources of the IVS GeoVLBI source database. We are manually gathering astrophysical data and information on each of those 173 sources, and planning to deduce individual behavioral pattern for each of them. In the near future, we will use these data combined with the Metsähovi light curves to test the capabilities of the approach described above.

A Chandra HETG analysis of the X-ray line features of Cygnus X-3

Petri Savolainen (Aalto University Metsähovi Radio Observatory), Michael L. McCollough (Smithsonian Astrophysical Observatory), Diana C. Hannikainen (Florida Institute of Technology)

Cygnus X-3 is an enigmatic system with a compact object, possibly a black hole, in a tight 4.79 h orbit around a Wolf- Rayet companion. The X-ray spectrum is rich with features from H-like and He-like emission lines from photoionized heavy elements, some of them with P Cygni profiles which indicate a strong wind from the mass donor. The photoionized nature of the emission is attested to by prominent Radiative Recombination Continua (RRCs) detected in the spectrum. We present an analysis and comparison of Chandra grating spectra from several different states of activity (quenched, major flare, transition, and quiescent states), also using concurrent RXTE data where available to establish the emission state and the continuum. Results from line profile fitting and photoionizational modeling are presented.

A simulated regolith medium for multi-wavelength studies

Olli Wilkman (University of Helsinki), Karri Muinonen (University of Helsinki), Hannu Parviainen (Instituto de Astrofísico de Canarias), Jyri Näränen (Finnish Geodetic Institute)

Effects arising from the small-scale surface structure are significant in remote studies of regolith surfaces on atmosphereless solar system bodies, such as the Moon, Mercury and the asteroids. The important properties determining these effects are the porosity of the regolith and the roughness of the interface between the bulk material and empty space.

We concentrate on the regolith effects in visible light photometry and X-ray spectrometry. The fluorescent X-ray spectrum induced by solar X-rays contains information about the elemental abundances of the surface material, while the photometry can be used to constrain surface properties such as porosity.

We have developed a computer model simulating a regolith medium consisting of spherical particles with variable size distribution and properties. The bulk properties of the medium, such as porosity and surface roughness, can be varied. The model can then be used in ray-tracing simulations of the regolith effects in both visible light scattering and X-ray fluorescence. In photometric studies the scattering law of the constituent particles can be chosen to take into account scattering phenomena such as coherent backscattering. In the X-ray simulations, we can choose the elemental abundances of the material and the spectrum of the incident X-ray radiation. The ray-tracing simulations then allow us to determine the characteristics of the emitted radiation in different observational geometries.

We present results from various studies which have been based on our regolith model. The model has been used to simulate the regolith effects on X-ray fluorescence spectra under specific situations. These can be compared to laboratory measurements. The visible light simulations have been applied in a study of the shadowing effects in photometry.

The model was also used in a study of lunar photometry from SMART-1/AMIE data. Applications in the analysis of X-ray spectrometry from the BepiColombo MIXS/SIXS instruments are planned. An application of the model to produce a numerical scattering law for asteroid surfaces is currently in progress.

Because in real observations the actual surface properties are unknown, they must be estimated somehow in order to take their effect into account. The advantage of our approach is that we can use the same regolith model to simulate both light scattering processes and X-ray fluorescence. Combining photometry with X-ray spectroscopy can allow us to better constrain the surface properties inferred from the data.

Formation of Early-type Galaxies Through Mergers of Gas-rich Disk Galaxies

Heidi Yli-Kankahila (University of Helsinki)

I introduce the current understanding of the formation of intermediate mass elliptical galaxies through mergers of gas-rich disk galaxies. Different properties of the progenitor galaxies (e.g. gas fraction, mass ratio, orbital geometry) are presented and their effects on the resulting merger remnant are considered. Different evolutionary phases taking place during the merger, such as star bursts and termination of star formation and their causes are discussed. Finally, the properties of the merger remnant (e.g. M_{BH}/M_{bulge} relation and M_{BH}/σ relation) are examined and compared to those of elliptical galaxies.

NON-RESEARCH TALKS

Transit of Venus

Joni Tammi (Aalto University Metsähovi Radio Observatory)

A rare astronomical phenomenon occurs during our meeting; in the morning of Wednesday 6th of June, 2012, Venus moves exactly between the Earth and the Sun. Transits of Venus happen in pairs with eight years between two transits, and an alternating gap of 105.5 and 121.5 years in between the pairs, the total cycle taking 243 years. This year's transit is the second of this pair and the seventh transit ever observed. Before 2004 no human alive had seen the transit, and after this wednesday, no human alive will see one again.

Due to the more than a century between the transits pairs, each event has been observed with very different equipment an in a very different astronomical context. These observations have been applied to various problems ranging from calculating the distance of the Sun to refining tools for extrasolar planet search.

I will give an overview of the basic celestial mechanics behind the transit cycles and the observations, and describe the astronomical perspectives of the previous observations from the first observation in 1639 by a lone English astronomer, to national expeditions in the 18th and the 19th century, and all the way to international real-time collaborations of thousands of amateur astronomers around the world in 2004. Finally, I will explain the practical details for the viewing event for Wednesday morning at the conference site, weather permitting.

The NOT Science School

Rami Rekola (Tuorla Observatory, University of Turku)

There is more to the Nordic Optical Telescope than just research. The NOT has served as a perfect tool to educate many young astronomers who have served there as NOT students. Many Nordic observatories and astronomical institutions have used material from the NOT for their public outreach efforts. The NOT may also be used to attract young people to study in the fields of natural sciences and technology. Although this goes under the title of education, there is a new tinge to it. The NOT science school gives students at the senior secondary school level a chance to visit a professional astronomical telescope for an all encompassing experience. In just one year the experimental phase will be made available in the national level. Furthermore, as the coating on the cake this will be beneficial also to professional astronomers.