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Instrumentation for Astronomical Spectroscopy

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Keywords: Echelle spectrograph, Astronomical spectroscopy, Nasmyth adapter, Westerlund telescope, Microcontrollers, 3D printing

We will present the story of how we in-house upgraded Uppsala University’s telescope with an echelle spectrograph. The Westerlund telescope (WT), named after the Uppsala astronomer Bengt Westerlund [1], is a Cassegrain reflector with a 0.9 meter primary mirror, making it the second largest aperture for optical telescopes being used in Sweden [2]. Before starting this project, the WT was only equipped with a CCD camera, a basic filter set and an eyepiece [3]. As a result, the telescope has practically only been used in a single undergraduate observational astrophysics course at the university [4], thus most of its potential was being lost. We have expanded the capabilities of the WT, beyond the ability to take pretty pictures, by constructing a new echelle spectrograph including a new Nasmyth adapter. This will allow for a broader use of the WT, primarily in observational astrophysics courses, in addition it can also be a useful tool in other courses which have astronomical spectroscopy in the syllabus.

The project has consisted of two main parts, the construction of the echelle spectrograph and the Nasmyth adapter. The adapter consists of a CNC milled frame with four instrumental ports to be mounted at one of the telescope’s Nasmyth foci. Inside the frame there is a stepper motor with a folding mirror that rotates to select the correct instrument. For position calibration, an optical sensor was used. To control the motor we used an existing driver module from Trinamic [5] that, after some modifications, we connected to an Arduino microcontroller [6] together with custom electronics. The Arduino handles all communication with the driver module through a serial connection, but it is also directly hardwired to the optical sensor and the driver module for minimum latency. This has allowed for a more direct control of the motor, that was necessary to obtain a high precision during position calibration. We have developed a communications protocol for the Arduino which easily can be implemented in any environment that supports serial communication, making it future-proof. Because everything is handled through the Arduino only a single USB cable needs to be connected to a user’s computer. The motor and the optical sensor connects through a single custom made cable using a DIN-7 connector. Power for the motor is provided through the driver module which gets it’s power from an external PSU while the other components use the USB connection for power. To enclose all of the electronics, we have designed and 3D printed a weather sealed case. The case have been equipped with a control panel for manually setting the mirror position. Also, we have created an easy-to-use standalone application, with a graphical user interface, to change the position of the mirror inside the Nasmyth adapter, allowing the user to quickly switch between the different instrumental ports on the adapter with a single click.

We have then assembled and aligned the main components of the spectrograph (echelle grating, collimator unit, transfer collimator and CCD camera). Finally, we have tested the spectrograph with an (artificial) point source to check the spectral format, throughput, scattered light and ghosts. The next step is to test the spectrograph on a real star.

Bibliography


CRIRES+: A HIGH-RESOLUTION NEAR-INFRARED SPECTROPOLARIMETER FOR THE VERY LARGE TELESCOPE
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Introduction
CRIRES+ is the upgrade of the CRyogenic InfraRed Echelle Spectrograph at the ESO Very Large Telescope. This upgrade comprises the addition of a cross-disperser unit that will increase tenfold the simultaneous wavelength coverage of the instrument while maintaining CRIRES' high spectral resolution (R=100000). In addition we put in state-of-the-art detectors and overhaul the calibration unit, plus add a polarimetry unit and improve the stability and repeatability of the instrument. First light is expected in 2018 and the instrument will be offered to the community in 2019.

CRIRES+ will be an excellent instrument to investigate new research cases: atmospheric characterization of transiting planets, origin and evolution of stellar magnetic fields, and search for super-Earths in the habitable zone of low-mass stars among others.

In this poster, we will describe in detail the performances of CRIRES+ and showcase some of its science cases.
MAGNETIC FIELDS OF COOL STARS
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Introduction
Stellar magnetic fields govern a plethora of physical processes both in and around stars at most stages of their evolution - convection, rotation, accretion, winds, exoplanetary habitability, and more. In cool stars particularly, magnetic fields are ubiquitous, complex, and variable. The detailed origin of these magnetic fields is unclear and actively debated today.

In this talk I will present recent results and projects, aimed at improving our current understanding and characterisation of cool stars' magnetic fields, focusing particularly on young pre main-sequence stars - namely T Tauri Stars - and main sequence M dwarfs. The basic aim of this work is to reconcile magnetic field characteristics inferred based on two widely-used methods: polarimetry (interpreted using Zeeman Doppler Imaging), and magnetic line broadening measured using high resolution spectroscopy.

I will also report progress developing the CRIRES+ high-resolution, near-infrared spectrograph for the ESO Very Large Telescope, that will allow unmatched study of cool stellar and even substellar objects and that will be offered to the community in 2019.
Introduction

Dense circumstellar media enshroud some core-collapse supernovae. A circumstellar medium (CSM) can come from stellar winds, but eruptive mass loss is ostensibly an important CSM source for some supernova (SN) progenitor stars. In the past decade, sky surveys have revealed ~10 SNe preceded by outbursts of their progenitor stars in the final year before the SN. The SNe following these outbursts showed signatures of interaction between SN ejecta and a CSM. As SN ejecta sweeps up CSM, the interaction allows us to glean a part of the progenitor star mass loss history. The interacting SN iPTF13z showed a precursor outburst ca. 0.5 years before explosion. At late times, iPTF13z showed a series of remarkable re-brightenings, indicating that SN ejecta plowed into denser regions of a structured CSM (likely formed by a series of eruptions). Lasting and luminous interaction between SN ejecta and CSM makes it hard to tell whether a non-destructive outburst or a genuine core-collapse SN happened. This ambiguity is a major problem when we try to understand the precursor outbursts and their relation to core-collapse SNe. New surveys, like the Zwicky Transient Facility (with Stockholm Observatory involvement) at Palomar, will likely find more SN precursors and improve our understanding of them. I will present iPTF13z, introduce the field of SN precursor outbursts and suggest how they can help us understand SNe and the final years of supergiant stars.
THE EISCAT_3D RADAR SYSTEM AND ITS POTENTIAL USE IN ASTRONOMY

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Introduction

The EISCAT_3D radar system will be a world-leading international research infrastructure. It will be located in the Fenno-Scandinavian Arctic and it is designed to use the incoherent scatter technique to study geospace and to investigate how the Earth's atmosphere is coupled to space. EISCAT_3D will in its first stage consist of three phased array antenna radar sites located in northernmost Norway, Sweden and Finland that, thanks to modern signal processing and radar techniques, will be able to obtain observations with significantly higher spatial and temporal resolution than what is possible with currently operating radar systems. In addition, EISCAT_3D is designed to manage continuous operation and to be able to carry out simultaneous observations within a large volume of the ionosphere above northern Scandinavia, making it a good instrument for detailed studies of space weather impacts on the ionosphere as well as for model verification. The EISCAT_3D radar system will be operated by EISCAT Scientific Association and thus be an integral part of an international organisation that has successfully been running incoherent scatter radars for more than thirty-five years.

The present EISCAT radar systems are not only used for studies of the ionosphere, but also for surveys of meteors and for studies of interplanetary scintillations. In the latter studies the radar system is operating in passive mode, and thus functioning as a narrow-band radio telescope. In addition, Kilpisjärvi Atmospheric Imaging Receiver Array (KAIRA), a LOFAR-derived radio telescope system in northernmost Finland, has successfully been used together with the EISCAT VHF transmitter and acts as a testbed for EISCAT_3D techniques. The flexible design and the sensitive receivers of the future EISCAT_3D system will enhance these capabilities as well as enable more radio astronomical studies.
EXPERIMENTAL AND THEORETICAL OSCILLATOR STRENGTHS OF MG I AND SI I FOR ACCURATE STELLAR ABUNDANCE ANALYSIS

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Introduction

With the aid of stellar abundance analysis, it is possible to study the galactic formation and evolution. Magnesium and silicon are important elements to trace the alpha-element evolution in our Galaxy. For chemical abundance analysis, such as magnesium and silicon abundances, accurate and complete atomic data are essential. Inaccurate atomic data lead to uncertain abundances and prevent discrimination between different evolution models. Furthermore, atomic data of some elements including magnesium and silicon are scarce, particularly in the infrared region. We study the spectrum of neutral magnesium and neutral silicon from laboratory measurements and theoretical calculations. Our aim is to improve the oscillator strengths (\(f\)-values) of Mg I and Si I lines and to create a complete set of accurate atomic data, particularly for the near-IR region. We derived oscillator strengths by combining the experimental branching fractions with radiative lifetimes reported in the literature and computed in this work. A hollow cathode discharge lamp was used to produce free atoms in the plasma and a Fourier transform spectrometer recorded the intensity-calibrated high-resolution spectra. In addition, we performed theoretical calculations using the multiconfiguration Hartree-Fock program ATSP2K for magnesium and GRASP2K for silicon. This project provides a set of experimental and theoretical oscillator strengths. The theoretical oscillator strengths are in very good agreement with the experimental data and complement the missing transitions of the experimental data. We present an evaluated set of oscillator strengths, \(gf\), with uncertainties as small as 5%.
DATA MINING FOR "IMPOSSIBLE" ASTROPHYSICAL EFFECTS IN SEARCH FOR EXTRA-TERRESTRIAL INTELLIGENCE
Beatriz Villarroel and the VASCO team, (beatriz.villarroel@physics.uu.se)

Introduction
In the era of large astronomical surveys, it is now possible to efficiently search for objects having certain predicted signatures of astro-engineering, like Dyson spheres. However, these signatures can often be confused with signatures from normal astrophysical sources e.g. dust. We propose to replace the search for signatures of astro-engineering with a search for "physically impossible" (or extremely improbable) effects. Such an approach can teach us about presently unknown physical phenomena or - in the most favorable of circumstances -- identify interesting SETI targets for follow-up radio observations. But also, searches for failed supernovae and heavily dimming Active Galactic Nuclei (AGN) can benefit from such a sky scan. In this talk, I present an international project ('the VASCO project') where we search for signs of extra-terrestrial intelligence by scanning for objects that disappeared from the sky during the last decades. I will present the preliminary results from the project, discuss the ongoing work and our future plans within the VASCO mission.
FITTING A PHYSICAL MODEL TO FERMI GRB PROMPT EMISSION DATA, CREATING THE DREAM
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Introduction
The origin of prompt emission of gamma-ray bursts (GRBs) remains an unsolved problem. GRB spectra are typically fitted with empirically motivated models, which yield apparent decent fits to the data. However, the lack of inherent physical meaning of the parameters and the difficulties of consistently reconciling the empirical function with any underlying physical processes, it is becoming increasingly clear that we instead need to fit physically motivated models to the data.

In this talk I present our work of fitting a model for subphotospheric dissipation to Fermi GRB data. Using the numerical code from [1], we simulate a fireball scenario with a relativistic outflow in which photons and electrons interact via Compton and Inverse Compton scattering, synchrotron as well as pair production/annihilation, and with a dissipation process occurring below the photosphere. I will go over the physical scenario of our model, and discuss the techniques used to go from a numerical simulation to a model which can be fit to data. Our model provides acceptable fits to all spectral shapes found in our burst sample and the implications of successful and rejected fits will be discussed. I will also present parameter correlations, as well as constraints on the dissipation scenario and the consequences for the internal shock scenario of GRBs. This work is a direct continuation of the work presented in [2], and clearly shows the importance of fitting GRBs directly with a physical model, as well as provides a working example of a subphotospheric dissipation model for GRBs.

References
KECK/NIRSPEC OBSERVATIONS OF RED GIANTS IN THE GALACTIC CENTRE
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**Introduction**

We present ongoing work on a project determining detailed abundances of cool red giant in the very Galactic centre based on Keck/Nirspec observations that we have performed over the last two years. Due to optical extinction of up to 10 magnitude we observe in the K-band. New methodology is being developed to support these medium resolution observations (R=20000).
**Introduction**

I will present the preliminary work on the sample of type Ic Supernovae from the iPTF untargeted Survey.
SEEING STARS WITH THE CHERENKOV TELESCOPE ARRAY: 
INTENSITY INTERFEROMETRY – IMAGING STELLAR SURFACES

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Abstract

In many ways it is a golden age for astronomy. Spectacular new discoveries, for example the detection of gravitational waves, are very dependent upon instrumental development. The specific instrumental development that we report on, Intensity Interferometry (II), explores the possibility of improving the resolution of optical telescopes to 50µas, a factor of almost 100 on present capabilities [1]. This is difficult to achieve, if not impossible, by simply increasing the size of telescopes, for many reasons, both technical and financial. Intensity Interferometry (II), if implemented on the Cherenkov Telescope Array (CTA) currently being built on two sites in La Palma and Paranal, would record the light intensity – the photon train - from many different telescopes, up to 2 km apart, on a nanosecond timescale and compare them. The signal from the many pairs of telescopes would quantify the degree of correlation by extracting the second-order correlation function, and thus create an image. This is not a real space image. However we are able to invert the data by Fourier Transform and create a real image. The more telescopes that we have the better resolved and more physical is the image, holding out the possibility of observing sunspots on nearby stars (“starspots”) or watching binary stars orbit around each other or even directly imaging exoplanets as they traverse the disc of their own star in real time. Whilst we understand our own star, the Sun, very well we have little experimental knowledge of how representative it is of main sequence stars. To test the II method, at Lund Observatory we have set up a laboratory analogue comprising ten small telescopes observing an artificial star created by light from a laser. The method has been shown to work and the telescope array has now been extended in the laboratory to two dimensions.

We are also in discussion with other groups in Europe and around the world to explore the possibility of implementing this method with real telescopes observing actual stars. We plan to do this first with the prototype CTA telescopes being built by the Catania astrophysics group – the ASTRI telescopes – and ultimately with the Cherenkov Telescope Array (CTA) itself. A Science Group for Intensity Interferometry has now been set up within the CTA Consortium, of which Lund University is an integral part. An attractive aspect of this technique is that it is complementary to the principle goal of CTA, which is the exploration of high energy cosmic rays via the Cherenkov light they generate in the atmosphere. However this can only be done under the most demanding atmospheric conditions whereas II can be recorded when conditions are poor – for example with a bright Moon, during periods of turbulence or hazy conditions, and at marginal grey sky times such as pre-dawn and post-dusk. Two considerable advantages of installing such an II option on CTA are, firstly, the minimal marginal costs that would be incurred - since the 400M€ investment in the infrastructure is already being made - and, secondly, only a few telescopes would be needed to produce unique scientific results already in the early days when the CTA array is far from complete.

References

STELLAR ATMOSPHERES BEHIND TRANSITING EXOPLANETS
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Spatially resolved stellar surfaces
Atmospheric studies of transiting exoplanets require stellar background spectra to be known along the transit path while detection of ‘true’ Earth analogs require stellar microvariability to be well understood. Hydrodynamic modeling of stellar atmospheres is feasible for various stars but such models and their ensuing spectra have been tested in detail only for the Sun with its resolved surface features. Using exoplanet transits, we extend such spatially resolved spectroscopy to also other stars. During a transit, successive stellar surface portions become hidden and differential spectroscopy between various transit phases provide spectra of small surface segments temporarily hidden behind the planet. Such retrievals of spatially resolved stellar spectra have now been achieved for HD 209458 (G0 V) and HD 189733A (K1 V).

Exoplanet transit spectroscopy

Differences between the stellar signal outside, and during exoplanet transit, yield signatures from the then hidden stellar surface segments.

Even giant planets cover no more than $\sim$1% of any solar-type star, enabling high spatial resolution but demanding very precise observations. Simulations of spectral signatures indicate that ratios between line profiles during various transit phases may change by $\sim$0.5%, requiring very high signal-to-noise ratios of $\sim$5,000 or more to enable spectral reconstructions [1]. Such S/N ratios are not yet realistic for individual spectral lines, but can be achieved for cool stars by averaging over numerous lines with similar parameters. From observations of HD 209458 with the ESO VLT UVES spectrometer at a spectral resolution $\lambda$/$\Delta\lambda \sim$ 80,000, photospheric Fe I line profiles have been retrieved at several center-to-limb positions [2]. For HD 189733A, analogous results were obtained using data from the ESO HARPS spectrometer.

![Reconstructed Fe I profiles on HD 209458. Spatially resolved lines are not subject to rotational broadening and are substantially deeper than in the disk-averaged spectrum outside transit (dashed gray). During transit, the profiles shift towards longer wavelengths, illustrating both stellar rotation at the latitude of transit and the prograde orbital motion of the exoplanet. The solid blue curve is from close to stellar disk center, dashed dark-red curve is from closer to the limb. Planet size and positions are to scale.](image)

References
EST – THE EUROPEAN SOLAR TELESCOPE
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Abstract
The European Solar Telescope, EST, is a planned 4-m solar telescope. EST will be optimised to study the magnetic coupling between the layers in the solar atmosphere: from the deep photosphere to the upper chromosphere. This will require diagnostics of the thermal, dynamic, and magnetic properties of the solar plasma over many scale heights. To achieve these goals, the EST must use a suite of instruments that can simultaneously and efficiently produce 2D spectropolarimetric data with high spatial and temporal resolution. EST will be located on one the Canary Islands of La Palma and Tenerife.
In March 2016, EST was included in the RoadMap of the European Strategy Forum on Research Infrastructures (ESFRI).
EST is promoted by EAST – The European Association for Solar Telescopes which has 23 scientific institutes from 14 European countries as members.
I will review the EST project and its scientific background.

Figure 1 Artist's impression of the EST. EST Collaboration
A Monte-Carlo type simulation toolbox for small body dynamical astronomy.
D. Kastinen\textsuperscript{1,2}, J. Kero\textsuperscript{1}, A. Pellinen-Wannberg\textsuperscript{1,2}, J. Vaubaillon\textsuperscript{3}, M. Holmström\textsuperscript{1} and I. Mann\textsuperscript{4}, \textsuperscript{1}Swedish Institute of Space Physic (IRF), Box 812, 981 28 Kiruna, Sweden (daniel.kastinen@irf.se), \textsuperscript{2}Umeå University, Department of Physics, \textsuperscript{3}IMCCE, Observatoire de Paris, France, \textsuperscript{4}UIT-the Arctic University of Norway, Department of Physics and Technology

\textbf{Introduction}
Earth is bombarded daily by billions of dust-sized particles amounting to around 4-200 tonnes of extraterrestrial material. Those larger than a few tenths of a millimetre give rise to visible streaks of light on the night sky: meteors. In spite of the fact that the underlying orbital dynamics is well understood, it is still an open question how much extra-terrestrial material enters the Earth's atmosphere. Meteoroids are a unique link between a phenomena occurring in the Earths atmosphere, the meteor, and astronomical bodies, the parent of the meteoroid. Meteoroids also threaten the infrastructure in space and hypervelocity hits by micron-sized granules continuously degrade the solar panels and other satellite surfaces. Through their orbital elements, meteoroids can be associated to the interplanetary dust cloud, comets, asteroids or the interstellar space.

\textbf{Project description}
Our project will carry out Monte Carlo type statistical simulations using high performance computing to investigate the mass propagation of material from parent bodies to Earth, the fluxes of solar system nanometer-sized dust, and the influence of chaos on meteoroid streams. The developed software toolbox will be published as open source and designed for reuse. Simulations will be compared to observational data from spacecraft and ground based instruments. The simulations will provide calibrations to analyse measurements with novel pattern recognition and machine learning techniques and they may also reveal information about comets and asteroids that conventional astronomical observations cannot. The next generation atmosphere and geospace research radar EISCAT_3D will be able to measure up to hundreds of thousands of meteoroid orbits per day with unprecedented accuracy. Exploitation of such vast amounts of accurate orbital data e.g. for inclusion into static models for spacecraft mission planning will benefit from the development of advanced orbit association analysis methods.

\textbf{Preliminary results}
In the preliminary study \cite{Kastinen2016} for this project we presented a simulation producing synthetic versions of the 1933, 1946, 2011 and 2012 October Draconids meteor outbursts \cite{Kastinen2017}, comparing them with observational data and previous models, as well as fundamental methods for evaluating the results of this type of simulations using convergence criteria. The simulation reproduced the predictions and observations of the 1933, 1946, 2011 and 2012 October Draconids, including the unexpected but measured deviation of the meteoroid mass index from a power law in 2012 as compared to 2011.

\textbf{Possible applications}
\begin{itemize}
  \item Meteoroid dust stream modeling
  \item Meteor shower prediction
  \item Spacecraft hazard estimation
  \item Event -> effect probability distributions
  \item Modeling uncommon populations in the interplanetary meteoroid environment
  \item Testing of physical models of small bodies
  \item Artificial data sample generation
  \item Meteor observation analysis
  \item Comet dynamics
  \item Asteroid dynamics
  \item Chaos estimation and effect
  \item ...
\end{itemize}

\textbf{References}
LIMITS ON A POINT SOURCE IN SUPERNOVA 1987A
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Introduction
Supernova (SN) 1987A was a core-collapse SN in the Large Magellanic Cloud (LMC) and was detected on February 23 1987. The LMC is a satellite galaxy of the Milky Way at a distance of ~50 kpc. This makes SN 1987A one of the closest and most easily observable SNe, providing a unique opportunity for astronomers. The progenitor star of SN 1987A has been identified as a blue supergiant and the proximity also allows for spatially resolved studies of the early evolution of a SN and its transition into a SN remnant. The temporal evolution of the SN at almost every wavelength has been closely monitored ever since it was first detected. The existence and properties of the hitherto undetected compact object spawned by the explosion is one of the outstanding questions concerning SN 1987A.

Methods
We have obtained new observations in ultraviolet (UV), optical, near-infrared (NIR), and sub-millimeter and put constraints on emission from a point source in the remnant of SN 1987A using both images and spectra. Images are from observations by HST/WFC3 in UV, optical, and NIR; VLT/NACO in NIR; and ALMA at 212-247 GHz. Limits from images are determined by inserting point sources of increasing flux until a detection threshold was crossed. Spectra are from HST/STIS in optical through NIR, and VLT/SINFONI in the NIR H and K bands. Limits from spectra are taken to be the observed flux in spectral regions that are relatively free of spectral lines. Limits from literature are included to provide coverage in radio, infrared, and X-rays.

Results
Blue, red, and green are limits. Blue points are from unresolved images of the ejecta and equatorial ring combined [1-4]. Red triangles resolve the ejecta (this work). Semi-transparent green triangles are from super-resolved images using deconvolution methods [5-9]. Yellow squares are the Crab pulsar flux if it was located at the position of SN 1987A [10-13]. The black line is the blackbody emission from a sphere of radius 12 km and 2 million Kelvin at the distance of SN 1987A. No limits are corrected for dust in the ejecta created by the SN but are corrected for interstellar.

References
HUNTING FOR STRIPPED-ENVELOPE SUPERNOVAE WITH MASSIVE PROGENITORS
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Introduction
Supernova (SN) explosions of very massive stars missing their outer layers of Hydrogen or Helium, i.e. Type Ib/c and IIb SNe, are referred to as stripped-envelope SNe. However, in the last decade, observational evidence has been building that their progenitor stars may not be as high-mass as initially thought. Instead, they may be more intermediate mass stars that lost their envelope via binary star mass transfer. This new result begs the question, what fate befalls the more massive stars, observed in the local universe as Wolf-Rayet (WR) stars? On the basis of observations, some authors have suggested that virtually all of them fail to explode as SNe and instead directly form black-holes. While others have preferred a more balanced view to match observed core-collapse SN rates, where most stripped-envelope SNe form from more-intermediate mass progenitors in binaries, with a few still arising from massive WR stars.

In this new era of massive photometric surveys, we here at Sweden have uncovered new evidence for the existence of stripped-envelope SNe with potentially very massive progenitors, working alongside our international partners in several collaborations. Here, I summarize the recent developments in the field of stripped-envelope SNe that necessitate a serious hunt for their hidden massive progenitor stars. I also present early results where we have discovered several SNe with potentially very massive progenitors. Finally, I speculate about whether these observations are enough to lay the direct-to-black-hole theory to rest for the progenitors of stripped envelope SNe.
Abstract

The Swedish Allsky Meteor Network is a fully integrated system of self-reporting all-sky camera stations that deliver data for detecting and analysing meteors and fireballs occurring over Sweden. Starting from a single camera at Uppsala University in early 2014, the network currently consists of seven active stations, and a few more are expected to come online during 2017.

The original driver for setting up the network was to obtain objective references for (often exaggerated) reports in the media of fireballs and other bright transient events in the night sky, and use these to educate the public on the physics of meteors. In addition, detailed modelling of the flight of meteoroids through the Earth's atmosphere shows that several events of the last years are likely to have been meteorite-dropping events. Given the scarcity of meteorites with known orbits, localizing such meteorites is extremely valuable, but also difficult.

The network relies for a large part on contributions from amateur astronomers, primarily driven by the need of a geographical spread of observing stations. And because fireballs do not respect international borders, obtained data is automatically shared with similar networks in Denmark, Norway and Finland.

In this talk I will present the network and some of the latest results, as well as touch on the open issues in the flight modelling of meteoroids.
INTRODUCTION

As part of a pedagogical development project funded by the Faculty of Science and Technology at Uppsala University, we have developed a series of exercises that aim to teach basic-level astronomy students how to navigate the night sky using freeware, multi-platform astronomy apps for smartphones and tablets. Apps of this type allow for augmented-reality observations and effortless identification of celestial objects under any sky conditions – even observations carried out in the daytime and observations of objects that are located below the horizon. In these exercises, students gain hands-on experience in identifying bright astronomical objects, are introduced to the spherical coordinate systems used in astronomy, gain insights about how the night sky changes with observer position and over time, and also learn a bit about the difference between astronomy and astrology. So far, exercises of this type have been used in three different astronomy courses at Uppsala University. In this presentation, we will describe the content of these smartphone exercises, the problems faced during the project and report on the measured learning outcomes of the exercises.
THE JAMES WEBB SPACE TELESCOPE: A NEW WINDOW ON THE HIGH-REDSHIFT UNIVERSE
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Introduction
Next year, the James Webb Space Telescope (JWST) will open a new window on the high-redshift Universe, with the potential to completely transform our understanding of the first billion years of cosmic history. Our team has over a number of years prepared for this revolution by modelling the spectral signatures of the various types of high-redshift (z=6-15) objects that are likely to be within JWST reach. This includes galaxies with high levels of Lyman continuum leakage (the galaxies that supposedly reionized the Universe), galaxies dominated by the light from the very first generation of stars (population III galaxies), direct collapse black holes (potential progenitors of the first quasars) and stars powered by dark matter annihilation (so-called dark stars). In this talk, we will present an overview of the JWST mission and the exciting possibilities for high-redshift discoveries that lie ahead.
EXPLORING ICY MOON EXOSPHERES WITH THE SUBMILLIMETER WAVE INSTRUMENT ON JUICE

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Context: The JUICE Mission
The Submillimetre Wave Instrument (SWI) is a spectrometer/radiometer instrument which will fly on ESAs JUpiter Icy Moons Explorer (JUICE). Planned for launch in 2022 and arrival at Jupiter in 2030, the ten instruments on JUICE will spend at least three years making detailed observations of the giant gaseous planet Jupiter and three of its largest moons: Europa, Ganymede, and Callisto.
The overarching science goals of the mission are (i) to give a better insight into how gas giant planets and their satellites form and evolve, (ii) shed new light on the potential for the emergence of life in Jupiter-like exoplanetary systems.

The Instrument
SWI is designed to record continuum emission and high resolution spectra in two sub-mm bands (530-625 and 1080-1275 GHz, respectively) which cover several rotational transitions of water (H_2O) and its deuterated counterpart (HDO), but also of e.g. CO, O_2, CS, SO_2, HCN, CH_4, and NH_3. Parts of the instrument is built in Sweden and members of the SWI Science Team at Chalmers has been given the task to provide support for Swedish researchers who has an interest in the science return from SWI.

Proposed Exosphere Investigations
Models of the icy moon interiors based on Galileo data [1], [2] indicate that all of them may have sub-surface oceans, making them plausible candidates to harbour life. However, their composition is largely unknown. Sputtering and sublimation of the icy surfaces is the origin of their tenous exospheres, possibly occasionally enriched by plumes rising from the subsurface ocean, as has been observed for Europa [3]. The proposed Swedish science goals for SWI focus on obtaining better knowledge of the exospheres of Jupiter’s icy moons. Especially water, a main exosphere component in all three moons, may be the key to both atmosphere and moon formation: Its three-dimensional distribution will reveal how the atmospheres form and evolve, while the fraction of heavy water, the HDO/H_2O ratio, will pinpoint to what extent the moons consist of primitive materials and thus when and how they formed. Observations/detections of minor atmospheric species at the moons are also of particular interest from an astrobiology point of view, since the composition of sub-surface oceans is a crucial factor in determining their habitability.
Also, in preparation for the JUICE mission, we have attempted to use ground-based data from the on-line archive of the Atacama Large Millimeter Array (ALMA) in Chile to constrain the icy moon exosphere composition. We will present our results on CO towards Callisto.

References
STRIPPED-ENVELOPE SUPERNOVAE FROM THE CARNEGIE SUPERNOVA PROJECT
Francesco Taddia\textsuperscript{1}, \textsuperscript{1}Stockholm University/OKC

Introduction
I will present results from a series of 4 papers on stripped-envelope supernovae (SE SNe), which were observed in the optical and in the near-infrared by the Carnegie Supernova Project. 34 events were analysed, allowing us to develop a new method to estimate the host-galaxy extinction of this SNe, as well as to derive the properties of their progenitor stars.
Introduction
Comets are believed to be remnants from the formation of the solar system. The Rosetta mission followed a comet, 67P Churyumov-Gerasimenko, from a low activity state at 3.6 AU from the Sun until perihelion at 1.25 AU and then out again. As the comet approaches the sun it emits volatiles and dust, forming the well known comet tails. The comet atmosphere and dust interact with the surrounding medium, the solar wind. The interaction with the solar wind affects the comet atmosphere as well as to some extent its surface. We briefly review Rosetta observations of comet 67P, with emphasis on the solar wind interaction with the comet atmosphere. We show how a cavity forms in the solar wind around the comet, and how cometary ions, formed from ionization of the atmosphere, are accelerated downtail. Part of these cometary ion fluxes will likely precipitate, thus to some extent affecting the surface, not just the atmosphere.
RELATING ABSORBING HYDROGEN CLOUDS TO THEIR EMITTING HOST GALAXIES
Henrik Rhodin¹, ¹Dark Cosmology Centre, Niels Bohr Institute, Copenhagen, Denmark

Introduction
Strong absorption-lines in the spectra of background quasars tell of intervening absorbers which are thought to probe the outerskirts of gaseous galaxies. Targeting host-galaxies of the most metal-rich absorbers optimises the detection-rate because these systems are more massive and brighter. In this talk, I will present the latest results from a spectroscopic campaign using the VLT/FORS2 instrument to search for such hosts!

By combining spectral information with multi-band photometry, we are able to explore scaling relations and the distribution of parameters that connects absorber to emitter. In addition to the intrinsic relation between these, one can use the absorption as a selection criteria when picking out a galaxy sample. This allows us to investigate how relations retrieved with different selection criteria compare to each other.
GET MORE WITH LESS: ASK MORE TO YOUR DATA USING STACKER A (SOON TO BE) OPEN ACCESS STACKING TOOL FOR INTERFEROMETRIC DATA
Jean-Baptiste Jolly¹, ¹Chalmers University of Technology (jean.jolly@chalmers.se)

Introduction
When it comes to high-redshift galaxies, limited signal is the main restriction to observations, and many galaxies remain undetected or only weakly detected in multi-wavelength surveys. And yet, such a multi-wavelength approach is necessary for galaxy evolution studies. Stacking of data offers a unique way to bypass this problem. With the major advances in mm and radio interferometry, extensive surveys are becoming available and stacking is becoming increasingly more popular. The statistical approach of stacking is essential in light of the synergy between modern telescopes (ALMA, VLA, JWST, VLT, HST ...).

We built an open access stacking tool for interferometric data that offers the possibility to stack, not only images but also directly the visibilities, known as Stacker. While the first version of stacker focused on stacking of continuum data, we are now expanding this to spectral line stacking. Along with the stacking algorithm, the Stacker package includes a set of statistical tools, such as means to perform various Monte Carlo simulations, for a proper analysis of the stacking results.

I will present the new and improved Stacker, which will enable further study of mm and radio spectral line observations of high-redshift galaxies discovered with other modern facilities. I will discuss the performance along with the challenges of spectral line stacking, as well as show science examples.
METEORS: THE METEOROID MASS AND ORBIT DISTRIBUTION
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Introduction

Earth’s atmosphere is daily bombarded by about 4-200 tonnes of extraterrestrial material - billions of dust-sized particles. Those larger than a few tenths of a millimetre give rise to visible streaks of light on the night sky: meteors. It is important to monitor the extra-terrestrial dust flux in the Earth’s environment and into the atmosphere. Meteoroids threaten the infrastructure in space and hypervelocity hits by micron-sized granules continuously degrade the solar panels and other satellite surfaces. Through their orbital elements, meteoroids can be associated to the interplanetary dust cloud, comets, asteroids or the interstellar space.

Radar and Spacecraft Observations

The meteoroid mass influx to the Earth’s atmosphere spans impactor sizes from dust to huge impactors. A combination of a variety of methods is therefore required to study it. Sub-millimetre-sized meteoroids are most numerous and can be detected with sensitive radar systems due radio wave scattering from the plasma they give rise to when interacting with the atmospheric constituents at around 100 km height. Meteor head echoes are radio waves scattered from the intense regions of plasma surrounding and co-moving with meteoroids on their atmospheric flight, and allow mapping the meteoroid trajectories of faint meteors with high accuracy [1]. We use their orbital element information to study the connections between the meteoroids and their parent bodies, which is an important step in order to generalise the observations to solar system meteoroid distributions and mass influx estimations [2]. Studying the dynamics of very small dust particles requires using in-situ detectors in space or collection in the atmosphere. One in-situ method is the detection of hypervelocity impacts on a spacecraft body using electric field instruments [3].

Infrasound observations

Atmospheric entry of metre-sized and larger objects occur very seldom, but on the other hand give rise to notable effects in addition to light production, and in rare cases extensive damage when the shock wave reaches ground. Depending on atmospheric conditions, sensor arrays sensitive to sub-audible sound pressure waves (infrasound) can register sizeable meteor events over distances of thousands of kilometres. The Preparatory Commission for the Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO) operates a global network of infrasound stations in the frame of their International Monitoring System (IMS). In addition to monitoring nuclear explosions, the network has proven useful to monitor meteoroid atmospheric impact events. IRF operates a national network of four infrasound stations, which register regional events and complements nearby IMS stations.

THE REAWAKENING AND RISE OF LUNAR RESEARCH
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Introduction
The moon has always attracted the imagination of mankind. A peak in the interest in the Moon was reached in the 60ties and 70ties with the famous Apollo missions. Afterwards however, the interest in in-situ research of the Moon faded. The Moon was considered to be a well known, even boring object.

Renewed interest
It was not until the start of the new millennia where with a series of new spacecraft missions this interest was renewed. Missions like the Chandrayaan-1[1,2], Kaguya[3], Arthemis[4], Chang’e[5], among others, showed that the Moon has a very complex interaction with its environment, the solar wind and the Earth's magnetosphere. And, unexpectedly, water signatures were discovered in the lunar surface. This lead to a new way of thinking about atmosphere-less bodies in the solar system.

Chang’e 4
An current example for in-situ lunar research is the Chinese Chang’e 4 mission. Chang’e 4 will for the first time land on the lunar far side. Chang’e 4 carries the Advanced Small Analyser for Neutrals (ASAN) instrument developed and built at the Swedish Institute of Space Physics. The instrument will investigate the solar wind interaction with the lunar regolith from a vantage point of less than one meter from the surface. The measurements will complement similar measurement performed from orbit by Chandrayaan-1[6] and have the potential to address the riddle of how water is produced in near surface lunar regolith.

References
CHARACTERISING EXOPLANET ATMOSPHERES, MAGNETOSPHERES AND STELLAR WINDS FROM ENERGETIC NEUTRAL ATOM OBSERVATIONS

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Introduction
We briefly review observations of energetic neutral atoms (ENAs) in the Solar System. Then we focus on the populations that could be remotely observed in other stellar systems, and we present how Lyman-alpha observations of transiting extrasolar planets could detect ENAs near these planets. We also discuss the problems and uncertainties in interpreting such transit spectra. Finally, we conclude with an outlook to future observations, and possible directions in modeling.

Ly-a Transit Observations
The first published high resolution Ly-a transit spectra was from HD 209458b [1], and there has been a debate in the literature on the interpretation of these spectra. It has been suggested that they show the thermal escape of hot hydrogen [1]. Another possibility is that natural broadening of the spectra is responsible, and the hydrogen is not escaping [2]. A third interpretation is that the observed hydrogen are ENAs [3] (see Fig. 1), and that the observation does not constrain the state of the exosphere, but can instead provide information on the stellar wind, and the magnetization of the extrasolar planet [4]

Energetic Neutral Atoms
Energetic neutral atoms (ENAs) are produced wherever energetic ions meet a neutral atmosphere. By energetic we mean that the ions have a much greater velocity than the thermal velocities of the exospheric neutrals. During the charge exchange process, an electron is transferred from the neutral to the ion, resulting in a neutral atom and an ionized neutral. Due to the large relative velocities of the ions and the exospheric neutrals, the momenta of the individual atoms are preserved to a good approximation. Thus, the produced ENAs will have the same velocity distribution as the source population of ions [3]. This enables remote characterization of the interaction between planets and stellar winds.

Planetary System ENAs
As solar wind ENAs have been observed at every planet in the solar system where ENA instrumentation has been available, the production of energetic neutral atoms from charge exchange between solar wind protons and neutral hydrogen should also occur at extrasolar planets.
THE JAMES WEBB SPACE TELESCOPE: A NEW WINDOW ON THE HIGH-REDSHIFT UNIVERSE
Matthäus Schulik\textsuperscript{1}, Bertram Bitsch\textsuperscript{1}, Elena Lega\textsuperscript{2}, Anders Johansen\textsuperscript{1}, \textsuperscript{1}Lund Observatory, 22100 Lund, Sweden, \textsuperscript{2}Observatoire de la Côte d'Azur, 06304 Nice, France

Introduction
New observations indicate ongoing formation of gas giant planets in protoplanetary discs, like LkCa15 \cite{1} and HD100546 \cite{2}. Those planets must be in the course of accreting gas and/or dust, but the interpretation of imaging data needs a clear understanding of the underlying accretion physics.

Our work
In the light of new theoretical work on gas accretion onto low-mass \cite{3} and high-mass \cite{4} planets, it seems reasonable to re-think the paradigm of classical gas giant formation onto rocky cores. We aim to understand gas accretion onto planets of saturnian masses. Those should exhibit the highest accretion rates \cite{5} and thus their growth should be the easiest to measure in simulations. Our numerical experiments show complex flow and feedback structures from the planet into the disc. We discuss the underlying physics and implications for the theory of gas giant formation as well as observations.

References
\begin{enumerate}
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\item B. Ayliffe and M. Bate (2009) MNRAS, 393, pp. 49-64.
\end{enumerate}
POLARISATION OF CYGNUS X-1: RESULTS FROM POGO+
Mette Friis¹, ¹KTH, school of engineering

Introduction
PoGO+ is a balloon-borne X-ray polarimeter flown from the Esrange Space Center in the summer of 2016. During a 7 day flight it observed two celestial sources, the Crab pulsar/nebula system and the X-ray binary Cygnus X-1. I will present the polarisation measurements and discuss how the results affect current models for the two sources, with focus on Cygnus X-1. The X-ray binary comprises a black hole, accreting matter from the stellar wind of its companion star. The binary itself is unresolved, with the only direct clue to orientation (with respect to us) coming from a radio jet. With polarisation measurements in hard X-rays, we have probed the geometry of the system in the near vicinity of the black hole. We use these results to test proposed models, providing strong constraints on the symmetry and/or inclination of the system.
VENUS: A SUPER-EARTH PLANET IN OUR SOLAR SYSTEM
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Abstract
Venus is the closest neighboring planet of us. Apart from the Sun with a distance of ~0.72 AU, Venus is embedded inside the habitable zone of our Solar System. Venus is characterized by the similar size of the Earth. If Venus were in the extra-solar system (or if we were living in another solar system), Venus would be categorized as super-Earth in the habitable zone of the parent star. Venus is characterized by the slow rotation, little H2O but the thick CO2 atmosphere and resulting high pressure (90 atm) and temperature (700 K) at the surface, as well as the very high-speed wind. In addition, recent studies of super-Earth planets (e.g. Kepler-69c) suggest that their characteristics may be close to Venus, rather than the Earth [1,2]. Therefore, we can say that Venus is a typical super-Earth object. Due to its proximity, we can even visit Venus directly by space probe; this is the most advantageous characteristics of Venus in terms of Solar System exploration and exoplanet studies.

European Space Agency sent their first probe to Venus in 2005. The space probe, named as Venus Express, aimed to investigate the structure and dynamics of the Venusian atmosphere [3]. After >8 years operation, the Venus Express mission was terminated in 2014 due to the lack of the fuel, and in early 2015 it went down to the thick Venusian atmosphere. A Swedish contribution to the Venus Express mission includes a suite of charged and neutral particle detectors called Analyser of Space Plasma and Energetic Atoms (ASPERA-4). ASPERA-4 was designed and developed by the lead of Swedish Institute of Space Physics, Kiruna [4]. The main scientific objective of the ASPERA-4 is to quantify the amount of oxygen (and related) ions escaping from the Venusian atmosphere due to the solar wind (stellar wind) forcing. Then, we can further constrain the history of the water contents in the Venusian atmosphere [5].

In this presentation, we will overview the Venus Express/ASPERA-4 outcomes on its Venus studies. The presentation focuses the topics relevant to the future implication to the exoplanet (super-Earth) studies.

References
DYNAMICS OF THE WINDS AND DUSTY ENVIRONMENTS IN T TAURI STARS

Introduction
We have carried out a long series of simultaneous spectroscopic and photometric observations of the classical T Tauri stars RY Tau and SU Aur with the aim to quantify the dynamics of the accretion and outflow at the time scales from days to years.

It is shown that dust in the disk wind is the main source of photometric variability of these stars, and that the dust occults the star but not the surrounding volume of ionized gas. In RY Tau we observed a correlation of between the outflow velocity and the stellar brightness. We propose that magnetospheric ejections influence the flow of the inner dusty wind. These magnetospheric ejections change with time. We find that monitoring of the H-alpha line profile variability may reveal the length of magnetic cycles in T Tauri stars.
CATALOGING STELLAR ACTIVITY TO DISENTANGLE THE SIGNATURES OF PLANETS
Rachael Roettenbacher¹, ¹Stockholm University (rachael@astro.su.se)

Introduction
Stellar magnetic fields affect the surfaces of cool stars in a variety of ways including through the suppression of convection (seen as localized dark regions known as starspots). The number and size of starspots depends on the star, but these magnetic features are known to impact photometric and spectroscopic observations. In transit photometry, radial velocity, and microlensing observations, some potentially planetary signatures have been proven to be caused by starspots.
Here, we discuss our efforts to improve the identification and characterization of planets hosted by active stars. To begin disentangling the signatures of stellar magnetism and planets, we image active stellar surfaces with a variety of state-of-the-art techniques. Our combination of light-curve inversion, Doppler, and interferometric aperture synthesis images is aimed at creating a catalog of stellar activity that will allow for an understanding of how stellar activity manifests and evolves on different types of active stars. We combine single epoch observations using all three imaging methods and multi-epoch light-curve inversion of data sets such as the Kepler archive to create the most complete study of stellar surfaces possible. With this unprecedented analysis of stellar activity, we will be able to more easily diagnose a detection as that of a planet or stellar activity and provide better opportunities to pull planetary signatures out of data otherwise obscured by starspots.
A CIRCUMSTELLAR SHELL AROUND A SUPERLUMINOUS SUPERNOVA REVEALED BY A LIGHT ECHO
Ragnhild Lunnan¹, Stockholm University

Abstract
Wide-field optical time-domain surveys provide an opportunity to discover and decipher new types of transients. One such discovery in the past decade is a new class of "superluminous" supernovae (SLSNe), which have peak bolometric luminosities 10-100 times those of normal core-collapse and Type Ia SN, and whose progenitors and energy sources are still debated. I will report on a surprising result from a late-time spectroscopic survey of SLSNe: the discovery of a shell of circumstellar material (CSM) around the supernova, revealed by absorption and emission in Mg II from the shell in an "echo" of the supernova light. The blueshift of the absorption lines allow us to measure the velocity of the CSM shell, and the time delay between the blueshifted and redshifted emission directly constrains the size of the shell. While pre-supernova mass loss in massive stars is not uncommon, this kind of observation is nearly unique, with the closest analogue being the ionization of the ring around SN1987A by the supernova flash. I will discuss both the circumstances that made this CSM signature observable in this case, and the implications for superluminous supernova progenitors and mass loss.
NEWS FROM THE GAIA MISSION
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Introduction
We want astronomy, science in general, and our research to reach a wide public. We want to share the excitement. Sometime we just want to get on with the science. At Onsala Space Observatory we've learnt some things about communicating with mass media, and at Populär Astronomi magazine we like to think we are part of the media. I'll share some experience and ideas that could be useful in a constantly changing media universe.
SOLAR EUV AND SOLAR WIND OVER 4.6 BILLION YEARS - EFFECTS ON THE MARTIAN ATMOSPHERE

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Introduction

Extreme Ultraviolet (EUV) observations of G-type stars of varying ages have provided models for the evolution of the Sun’s ionizing radiation and solar wind conditions [1,2]. The intense EUV and solar wind conditions in the early solar system are often suggested as an explanation for the thinning of the original Martian atmosphere given the lack of an intrinsic Martian global magnetic dipole. However the conductive Martian upper atmosphere forms an induced magnetosphere in the interaction with the Solar wind and its effect on atmospheric escape has not been well understood until recent years. Quantifying the effects of varying solar wind and EUV on the Martian plasma environment under the available modern conditions enables us to extrapolate the effects of the Sun’s changing environment on the Martian atmosphere over time.

Mars Express observations

Recent studies have combined measurements of atmospheric ion flows and solar wind conditions from IRF’s instrument package ASPERA-3 on Mars Express with Earth-based Solar EUV observations to reveal the effects on atmospheric ion escape to space [3,4]. Combining such models of the ion escape rate as a function of EUV and Solar wind with models of the evolution of solar wind and EUV we can estimate the influence of the solar environment on the Martian atmosphere over time.

Figure 1: Solar X-ray and EUV spectra for varying ages of the Sun based on TIMED/SEE measurements and spectral-intensity models by Ribas et al. [1].

Figure 2: Example measured atmospheric ion fluxes for two bins of Solar (1-118 nm) photon fluxes showing a corresponding increase in the atmospheric ion escape.

Implications

The integrated Martian atmospheric ion loss over time amounts to less than 0.1 bar since formation, implying that solar wind stripping and other ion loss mechanisms can not explain the lack of a dense atmosphere in the present era. Comparisons with ion escape from Venus suggest that an intrinsic global magnetic dipole is not to required for a planet to maintain a stable atmosphere even under intense solar wind conditions.

References

References
Introduction

ALTO is a wide field-of-view air shower array for very-high-energy (VHE) gamma-ray astronomy, proposed to be installed in the Southern Hemisphere at an altitude of about 5.1 km above sea level. The array will use water Cherenkov detectors, as in the HAWC observatory, but combined with scintillator detectors, to detect air showers induced by VHE gamma rays in the atmosphere. It will be designed to attain a lower energy threshold, better energy and angular resolution, and improved sensitivity. The array will consist of about 1250 smaller-sized detector units distributed over a circular area of about 200 m in diameter. Each detector unit will consist of a water Cherenkov detector and a liquid scintillation detector underneath which will preferentially identify muons, facilitating the background (cosmic ray) rejection, thereby improving the sensitivity. The background rejection will be further enhanced by the close-packed arrangement and the small size of the detectors which will allow a fine sampling of air-shower footprints at the ground.

In this contribution, we will describe the Monte-Carlo simulation of the experiment performed using CORSIKA and GEANT4 simulation packages, the reconstruction of air shower parameters, and the analysis for the signal/background discrimination based on the Boosted Decision Trees technique. We will also present the expected performance of the array in terms of reconstruction accuracies of the shower core, arrival direction, and energy of the primaries, as well as preliminary estimates of the energy threshold and sensitivity for a point-like gamma-ray source.
A MULTI-BAND ANALYSIS NGC6217: AN EXTENDED X-RAY JET FROM A COMPLEX NUCLEUS
Serena Falocco¹, ¹KTH Royal Institute of Technology (falocco@kth.se)

Introduction
NGC6217 is a nearby (z=0.005) spiral galaxy. A variety of multi band data highlights several aspects of its central core resulting in multiple classifications. A highly star forming region located near its central core is broadly accepted, while the evidence for a standard active galactic nucleus (AGN) is still discussed. It has been classified as a Low Ionisation Nuclear Emission Line Region (LINER) based on its optical lines by Nicholson+1997, and LINER galaxies are often associated with Low Luminosity AGN (LLAGN). Pietsch+2001 reported a jet emanating from the nucleus of the galaxy in the X-ray images from the Rössat archive. The structure is composed by three knots and it is extended over 19 kpc. We have studied four observations from XMM Newton satellite, studying the images and the spectra of the central core and its jet in order to understand their nature. The XMM images confirm the jet structure. The spectra of the central core are well represented by a complex starburst-AGN nucleus. Our study provides the first constrains on the spectral properties of the aligned knots showing that they are harder than the core, in agreement with other jets in the literature. The jet is one-sided and has no optical counterpart, as can be seen in additional images from HST telescope. The accretion rate estimated in our study is consistent with LLAGN in the literature known to host advection dominated accretion flows (ADAF). Our study highlights the complexity of NGC6217, which displays an extended jet emitted from the nucleus of the galaxy.
FINDING PLANETS AROUND NOISY STARS: A needle in a fiery haystack
S. Eriksson

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Introduction

The intensive search for exoplanets, planets around other stars, is now into its second decade, and the community of exoplanet hunters continues to chase the discovery of the first true twin to our own planet around a Sun-like star. Thousands of diverse exoplanets have so far been discovered, many by use of the radial velocity (RV) method. Through analysing the light spectrum of a star we can indirectly observe a planet by measuring its gravitational tug on the parent star as an induced velocity (e.g. Figure 1). For example, the Earth induces a motion of the Sun of just 9 cm/s.

With the upcoming implementation of the planet-hunting spectrograph ESPRESSO [1], we will finally have the precision required to detect Earth-twins in the habitable zone around other Sun-like stars. Because instrumental noise previously dominated observations, this impending achievement brought to light a significant issue that has so far largely been side-stepped by observers: stellar activity.

Stars are not quiet and docile. They have powerful magnetic fields that produce a range of activity phenomena such as starspots which can cause substantial noise in RV observations, hiding the faint but precious signals from small planets. Activity signals in the Sun, a relatively quiet star, can produce RV variations of several m/s [2]. At worst, activity can even mimic the presence of a planet, leading to false detections [3]. Given these circumstances it might not matter how precise our instruments are, as the signals of Earth-twins could remain overshadowed by their stars if we fail to develop tools and techniques to correct for stellar activity [4]. An interesting avenue in potentially correcting for activity is investigating its effects on individual spectral lines, which is a focus of my current research as a PhD student.

In my talk, aimed at a broad audience, I will discuss the search for exoplanets amid stellar activity, the effects of this activity on RV observations and potential solutions that can lead towards the full characterisation of planets potentially suitable for life.

Figure 1: Radial velocity curve of the exoplanet HD 32963 b (modified from [5]).

References

Introduction

Mass loss by a stellar wind is a decisive process for late stellar evolution. Through this wind, Asymptotic Giant Branch (AGB) stars are major contributors of synthesized elements and dust to their surroundings. The wind process is studied using dynamical wind models with the goal of developing a predictive theory of AGB mass loss crucial for stellar and galactic evolution. The most reliable method to measure mass-loss rates, and to provide constraints for the wind models, is through CO line observations, but further progress in this fundamental field is still limited by the large observational uncertainties, where the assumed size of the CO envelope is a major factor. To solve this problem we applied for a large program on ALMA (and were later rewarded time through a supplementary call) to directly measure the CO envelope sizes for 41 nearby AGB stars by observing the CO(2-1) and (3-2) emission using the ACA in standalone mode. The data will be used to develop the most accurate description of AGB mass loss, needed over a large range of wind properties, uniquely determine the gas-to-dust ratios of the sources, and provide a goldmine for legacy science for the evolved star science community. The data is being gathered in Cycle 4 and I will present the project and first results.
MODELLING THE ATMOSPHERIC MORPHOLOGY OF COOL GIANTS
Sofie Liljegren¹, ¹Uppsala University, (sofie.liljegren@physics.uu.se)

Introduction
Asymptotic giant branch (AGB) stars are stars approaching the end of their life. They are cool giants of low to intermediate mass that are violently bloated, pulsating and non-spherical, with heavy mass loss through a stellar wind. The mass loss makes these stars important for both for determining the initial-final mass relation for this mass range and for the galactic chemical evolution, as the wind enriches the interstellar medium with newly produced elements and dust.

Recently self-excited 3D star-in-a-box simulations of AGB stars, modelling the dynamical interior and lower atmosphere, have been calculated for a range of different stellar parameters. These models show presence of highly non-spherical structures in AGB stars, with convection cells of the scale of the stellar radii dominating the interior of the star, and large irregular shock waves moving through the atmospheres. High angular resolutions techniques are currently reaching a stage where these phenomena can be observed.

We investigate the morphology of the complex shock waves in the atmosphere, and implications that these 3D effects have on predictions from dust-driven wind models, which assume a spherically symmetric atmosphere. Mass-loss rates resulting from such models are used in stellar evolution codes, and any 3D effects may have an impact on our understanding of these late evolutionary stages.
JUPITER AND ITS SYSTEM: THE KEY TO UNDERSTAND HOW THE SOLAR SYSTEM WORKS.
Stas Barabash\(^1\) and the PEP Team, \(^1\)Swedish Institute of Space Physics, Kiruna, Sweden (stas@irf.se).

**Jupiter and the JUICE mission**
Galileo Galilei’s discovery of four large moons orbiting Jupiter four centuries ago spurred the Copernican Revolution and forever changed our view of the Solar System and universe. Today, Jupiter and its diverse collection of moons is seen as the archetype for giant planet systems both in our Solar System and around other stars throughout our Galaxy. A comprehensive characterisation of the Jovian system, from the churning gas giant and its enormous magnetosphere to the orbiting rock/ice worlds in all their complexity, will allow us to unravel the origins of the giant planets and their satellites and search for evidence of potentially habitable environments in the cold outer solar system. By dedicating a mission to explore the Jovian system with particular focus on Ganymede as a planetary habitat, the ESA JUpiter ICy moons Explorer (JUICE) will significantly deepen our understanding of the conditions for the emergence of life and how our Solar System works.

**JUICE mission scenario**
The JUICE mission will launch in September 2022, with an arrival at Jupiter in July 2030. After insertion into Jupiter orbit, JUICE will use multiple gravity assists via flybys of the Galilean satellites to shape a comprehensive orbital tour over ~3.5 years. After reducing the orbit period with Ganymede flybys, this tour will implement two close Europa flybys, then a series of Callisto flybys so as to reach an inclination of 22° with respect to the equatorial plane of Jupiter. At the end of the tour, JUICE will be set in a polar orbit around Ganymede, becoming the first spacecraft in history to enter orbit around an icy satellite in the outer solar system.

**JUICE payload**
The JUICE spacecraft will carry a highly capable suite of ten state-of-the-art scientific instruments. The remote sensing package includes spectro-imaging capabilities from the ultraviolet to the near-infrared, an imaging system and a sub-millimetre wave instrument. The geophysical package includes laser altimetry and radar sounding for exploring the surface and subsurface of the moons. The radio science instruments complement the remote sensing package (to enable probing of the Jovian/satellite atmospheres) and the geophysics package (enabling estimation of gravity fields). The in situ package includes a magnetometer, a radio and plasma wave instrument RPWI (Radio and Plasma Wave Instrument) as well as a particle package PEP (Particle Environment Package). PEP and RPWI are comprehensive suites led by the Swedish Institute of Space Physics in Kiruna and Uppsala to fully characterize plasma and plasma waves, neutral gas, energetic and relativistic particle populations as well as energetic neutral atom emissions.
SUBMILLIMETRE OBSERVATIONS OF WISE-SELECTED, DUSTY, LUMINOUS, HIGH-REDSHIFT GALAXIES
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Introduction
I will present JCMT SCUBA-2 850 μm submillimetre (submm) observations of 10 mid-infrared (mid-IR) luminous active galactic nuclei (AGNs), detected by the Wide-field Infrared Survey Explorer (WISE) all-sky IR survey and 30 that have also been detected by the NVSS/FIRST radio survey. These rare sources are selected by their extremely red mid-IR spectral energy distributions (SEDs). Further investigations show that they are highly obscured, have abundant warm AGN-heated dust and are thought to be experiencing intense AGN feedback. When comparing the number of submm galaxies detected serendipitously in the surrounding 1.5 arcmin to those in blank-field submm surveys, there is a very significant overdensity, of order 3-5, but no sign of radial clustering centred at our primary objects. The WISE-selected AGN thus reside in 10-Mpc-scale overdense environments that could be forming in pre-virialized clusters of galaxies. WISE-selected AGNs appear to be the strongest signposts of high-density regions of active, luminous and dusty galaxies. SCUBA-2 850 μm observations indicate that their submm fluxes are low compared to many popular AGN SED templates, hence the WISE/radio-selected AGNs have either less cold and/or more warm dust emission than normally assumed for typical AGN. Most of the targets have total IR luminosities ~10¹³ L☉, with known redshifts of 20 targets between z ~ 0.44-4.6.
SWEDEN SOLAR SYSTEM AS A PEDAGOGICAL TOOL
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Introduction
Sweden Solar System is the worlds’ largest scale model of the solar system with Globen in Stockholm representing the Sun, and the planets lined up in northwards from Globen. Artistic physical models created by professional artists represent the planets and a number of other astronomical objects. Distances and sizes are scaled according to 1:20 million, and the inner planets are all in the Stockholm area. The model of Venus is placed outside Vetenskapens Hus, at Albano University Centre. Although Sweden Solar System has a great pedagogical potential, it has up to now not been used much in education.

At Vetenskapens Hus we have developed two school activities using Sweden Solar System – one activity for grade 4-6 focusing on the planet Venus and another activity for grade 7-9 focusing on the Sun. Each activity takes 2-3 hours and combines science and art in order to increase students’ interest and understanding. Sweden Solar System is used to illustrate some astronomical phenomena and concepts, and is combined with other astronomical activities at Vetenskapens Hus. It is possible to develop similar activities for other astronomical objects and to extend the use of Sweden Solar System as a pedagogical tool to all parts of Sweden. In this talk we will present the two activities that have been developed so far and the reception they have received from the test classes. We will also discuss how the model can be used in education both as a local activity and as collaboration with different actors to develop a national educational activity.
REPLICATING OBSERVATIONS OF THE SUN’S MOTION AS DESCRIBED IN ICELANDIC MANUSCRIPTS FROM THE 12TH CENTURY

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Abstract
Old Icelandic manuscripts contain some interesting astronomical material, for example calendar calculations and solar observations. We know the names of some of the original authors though their work was not written down during their lifetime, but preserved orally for decades or even centuries. The primitive Nordic almanac year of 2x26 weeks (364 days) created problems in daily life and administration before Christianity was adopted and the Julian calendar introduced in 1000 AD. Thorstein Hallsteinsson, called “the Black”, found an inventive solution in the middle of the 10th century, thoroughly studied by philologists and mathematicians. This presentation, however, concentrates on observations of the sun made by Oddi Helgason, nicknamed “Star-Oddi”, who lived in northern Iceland in late 11th and early 12th century. He is still remembered for his timing of solstices and measuring changes in the sun’s declination between them. Oddi’s choice of the apparent diameter of the sun as an angular unit is remarkable. His conclusion was that the total change over 26 weeks from winter minimum to summer maximum was 91 units. In modern terms it means that the diameter of the sun is 47°/91=0,52° which is close to the actual mean value of 0,532°, contrary to the accepted value of 360°/216=1,67° in continental Europe at that time. Oddi’s mathematical model of the progression of increments in weekly observations approximates surprisingly well an accurate curve. The purpose of the poster is to illustrate and interpret Star-Oddi’s results and propose a plausible method, not documented in the manuscripts. Even if it is possible to track the sun’s coordinates along the horizon at sunrise or sunset, the most obvious procedure is to measure the sun’s altitude at culmination. But in order to apply the sun itself as a unit a hypothetical equipment could be a combination of pinhole camera and meridian circle. The image at the end of the camera tube is then used to calibrate a scale on the back side of the instrument. Hopefully a prototype will be tested this summer but comprehensive measurements on location may take a few years.

References
NEWS FROM THE GAIA MISSION
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Introduction
The Gaia mission was successfully launched in December 2013 and is more than half-way through its five-year observing campaign. The repeated whole-sky scans by the Gaia satellite will result in positions, parallaxes and proper motions to microarcsecond precision for about one billion objects within the Galaxy and in its surroundings. I will give a brief overview of the mission and present a few highlights from the first data release.
This paper aims at investigating what astronomy students and experts discern from the multitude of different disciplinary affordances available in Hertzsprung-Russell (HR) diagrams. HR-diagrams are extensively used in teaching astronomy at university level, but very little is known on what understanding students can take away from encounters with such disciplinary-specific representations [1]. Disciplinary-specific representations harbour many disciplinary affordances which are used to communicate disciplinary knowledge within a particular discourse [2]. HR-diagrams are no different in this perspective [3]. However, these representations are very specialized and the astronomical knowledge present in such a representation could be difficult for students to discern. For a student to be able to do this, (s)he needs to be able to “read” the representation using the “language” of astronomy, a competency related to Reading the Sky [4]. This is challenging for many students, but very little research has been identified addressing this issue. Learning astronomy, or any other discipline, involves a process of knowing “what to focus on in a given situation and how to interpret in an appropriate, disciplinary manner” [5]. The process of learning can be framed in terms of discerning the intended meaning of representations; what is referred to as disciplinary discernment [5]. Disciplinary discernment is defined as “noticing something, reflecting on it, and constructing meaning from a disciplinary perspective” ([5] p. 170). However, this disciplinary discernment depends on one’s disciplinary knowledge and can be described by a hierarchy called the Anatomy of Disciplinary Discernment (ADD). The ADD “encapsulates the increasing complexity of intended meaning of representations [...] It describes the ways in which the disciplinary affordances of a given representation may be discerned” (p. 174). The process of disciplinary discernment is done by the student [4], whereas the unpacking of disciplinary affordances of representations usually are done by the educators/professors [2]. In this paper, we present how disciplinary discernment from HR-diagrams can be described and addressed. The paper investigates and describes what astronomy students at different university levels, and astronomy educators/professors, discern from an examplary HR-diagram. Data from a web based questionnaire were analysed using the ADD framework. Preliminary results show (1) the developmental nature of disciplinary discernment from the HR-diagram by the participants and (2) the large discrepancy between disciplinary discernment by the astronomy educators and their students. We describe and discuss the qualitative nature of these differences and implications for teaching and learning astronomy.

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THERMAL COMPONENTS IN THE EARLY X-RAY AFTERGLOWS OF GAMMA-RAY BURSTS: A POSSIBLE SIGNATURE OF supernovae?
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Introduction
Early X-ray afterglows of gamma-ray bursts are usually well described by an absorbed power-law. However, a number of cases have been reported where this power-law model fails in representing the data and an additional thermal component is needed in the soft X-rays. The most notable such case is GRB 060218, which was accompanied by a supernova, SN 2006aj. The origin of the thermal components has variously been suggested to be supernova shock breakout, emission from a cocoon surrounding the jet or late prompt emission. In this work we analyze the X-ray spectra of 101 Swift gamma-ray bursts with known redshifts observed between 2011-2015 in order to search for new bursts with thermal components. Specifically, we compared the absorbed power-law model with an absorbed power-law plus a blackbody model to test for the presence of a thermal component. We report finding several new cases with a significant blackbody component. We compare our results with the previously reported cases and discuss the observations in terms of the different proposed scenarios.
VERY-HIGH-ENERGY GAMMA-RAY ASTRONOMY WITH THE ALTO OBSERVATORY
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Introduction
ALTO is a concept/project in the exploratory phase since 2013 aiming to build a wide-field VHE gamma-ray observatory at very high altitude in the Southern hemisphere. The operation of such an observatory will complement the Northern hemisphere observations performed by HAWC and will make possible the exploration of the central region of our Galaxy and search for Pevatrons, and to search for extended Galactic objects such as the Vela SNR and the Fermi bubbles. The ALTO project is aiming for a substantial improvement of the Water Cherenkov Detection Technique by increasing the altitude of the observatory in order to lower the energy threshold, by using a layer of scintillator below the water tank to optimize the S/B discrimination, by minimizing the size of the tanks and having a more compact array to sample the air-shower footprints with better precision, and by using precise electronics which will provide time-stamped waveforms to improve the angular and energy resolution. ALTO is designed to have as low an energy threshold as possible so as to act as a fast trigger alert to other observatories – primarily to the Southern part of CTA – for transient Galactic and extra-galactic phenomena. The wide field-of-view resulting from the detection technique allows the survey of a large portion of the sky continuously, thus giving the possibility to access emission from Gamma-Ray Bursts, Active Galactic Nuclei and X-ray binary flares, and extended emissions of both Galactic (Vela SNR, Fermi bubbles) and extra-galactic (AGN radio lobes) origin. The ALTO observatory will be composed of about a thousand detection units, each of which consists of a Water Cherenkov Detector positioned above a liquid Scintillation Detector, distributed within an area of about 200 m in diameter. The project is in the design study phase which is soon to be followed by a prototyping phase. The ALTO concept, design study and expected sensitivity together with the prototype status and plans for final deployment in the Southern hemisphere will be the subjects of this presentation.