Finnish Centre for Astronomy with ESO

Annual Report

2018

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FINNISH CENTRE FOR ASTRONOMY WITH ESO, ANNUAL REPORT 2018

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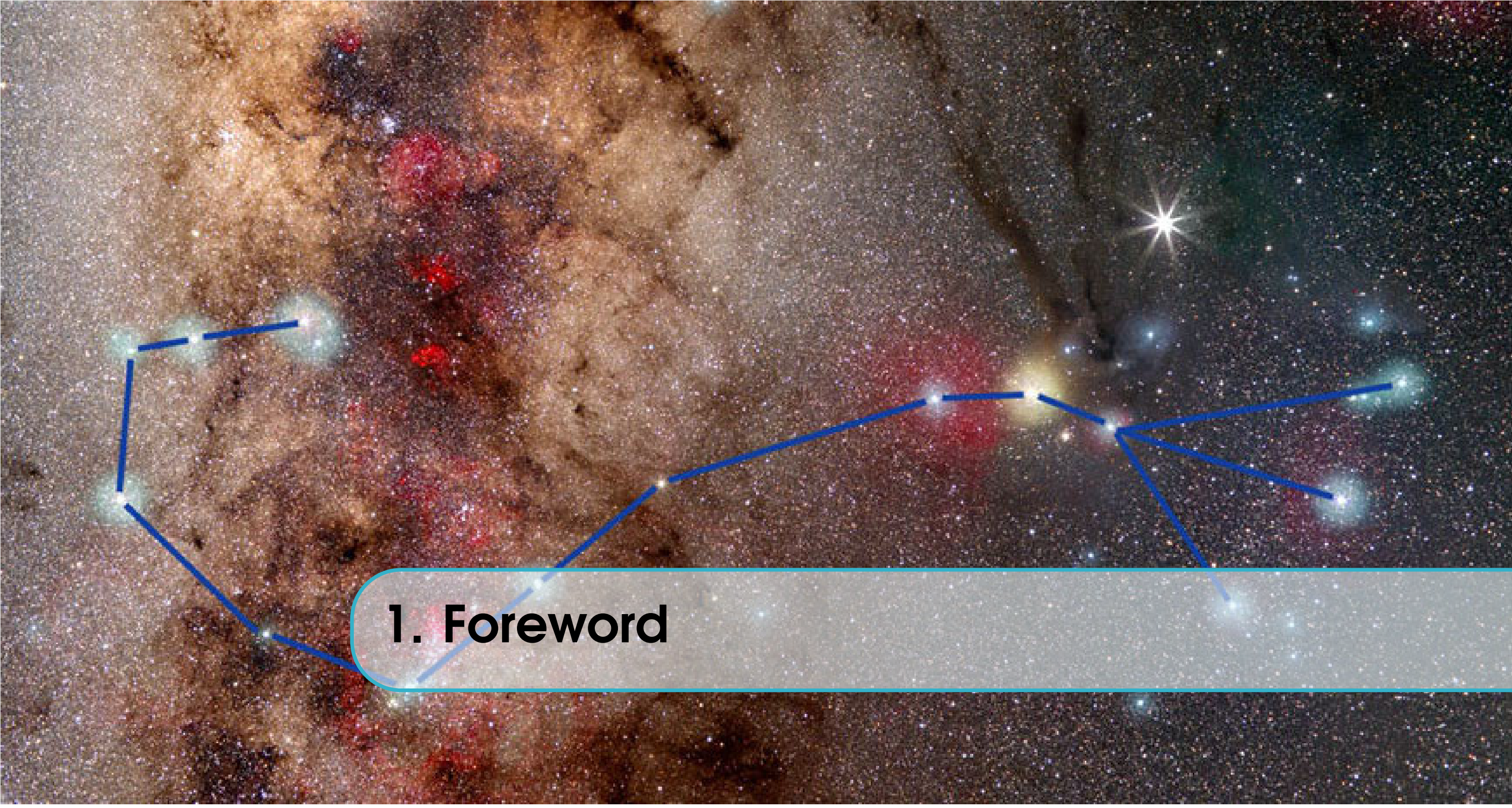
Based on a template by Andrea Hidalgo.

May, 2019

Cover: Construction site of E-ELT on Cerro Armazones (courtesy: ESO)

Contents



1. Foreword

Finland is a member of the European Southern Observatory (ESO) since 2004. ESO is a world leading astronomical research and technology organization, with 16 member states, headquarters in Garching, Germany, and three world-class observatories in Chile.

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

The year 2018 marked the 9th year of operation for FINCA, administratively a Special Unit of the University of Turku, and funded by the Ministry of Education and Culture, and by the participating universities (Aalto, Helsinki, Oulu and Turku). The highest decision-making body is the Board, chaired by Vice-Rector Kalle-Antti Suominen of the University of Turku, and comprising of two members from each participating university and one member from FINCA staff. The scientific activities of FINCA are overseen by an international Scientific Advisory Board (SAB), chaired by Prof. Susanne Aalto (Chalmers University of Technology, Sweden),

The research at FINCA covers a large range in contemporary astronomy, from cosmology, active galaxies, and galaxy formation and evolution, through properties of nearby galaxies, to supernovae and their progenitor stars, stellar activity and star formation in our own Galaxy. In our research, we use radio to gamma-rays multi-wavelength observational data from large ground-based and space telescopes, especially from the four 8m ESO Very Large Telescopes (VLT), and the Nordic Optical Telescope (NOT) on La Palma, Spain, in the optical and near-infrared. Observational research is supplemented by modelling, simulations and theoretical work, that are essential in understanding the physics behind the observations. Our research were reported in 64 refereed scientific articles, and some of them are highlighted in this Report.

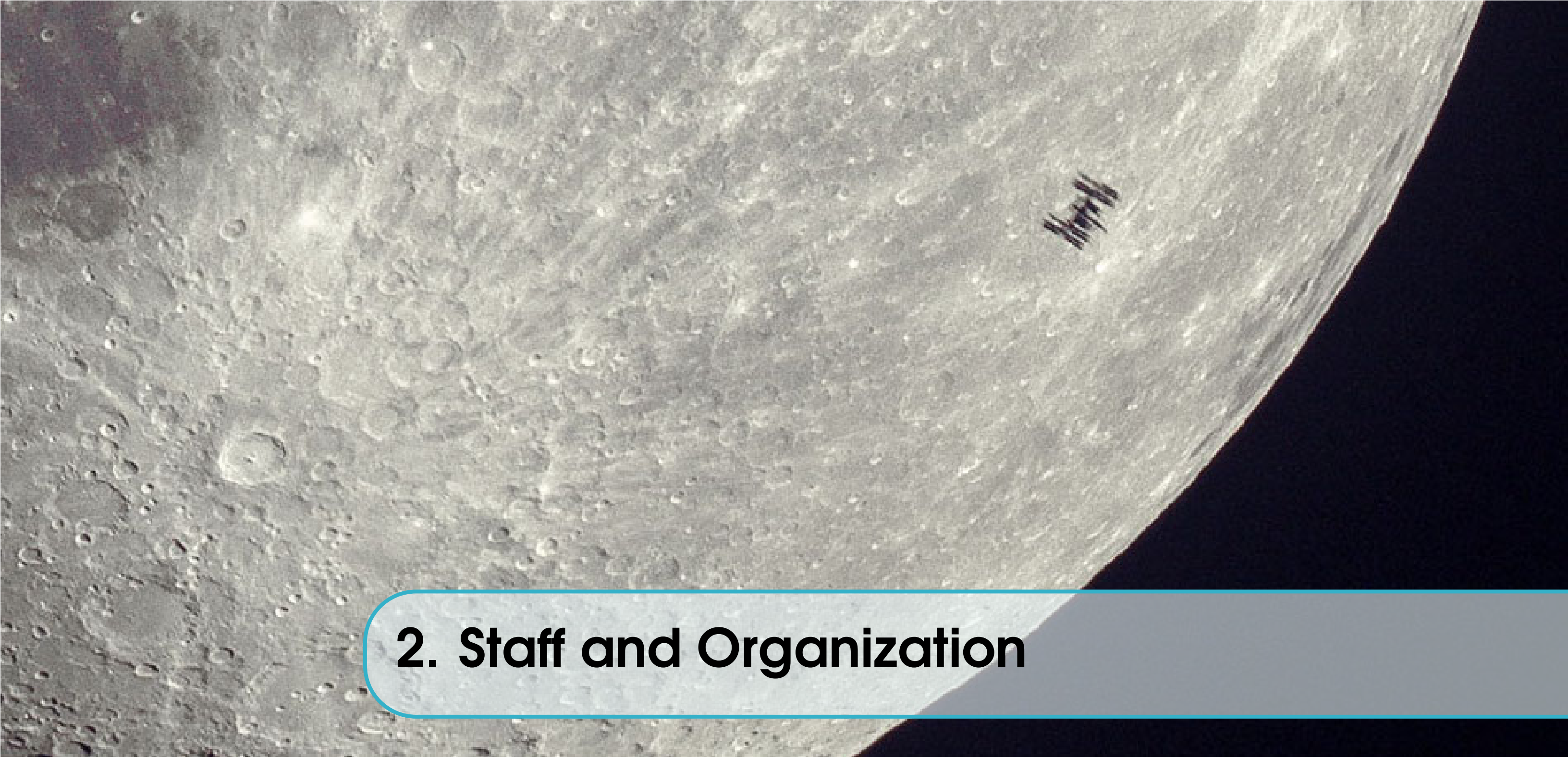
Our researcher training activities in 2018 focused on one hand in supervision of PhD and MSc students in the participating universities, and on the other hand in hands-on teaching of advanced observing, data reduction and analysis methods in observational astronomy as national collaboration. There was one such course held in 2018, the annual course on remote optical/infrared observing with the NOT. In addition, FINCA co-organized a practical course for Finnish high school students, also on remote observations with the NOT.

The construction of the ESO Extremely Large Telescope (ELT), a 39 m diameter giant for infrared and optical astronomy, is well underway, with Phase 1 instruments being constructed, Phase 2 instruments being in final design phase, all major contracts for the construction of the ELT been awarded, and construction started at Cerro Amazons. This keeps ESO on-track to remain in a world-leading position, when the ELT starts operations in 6 years time, bringing an enormous leap forward in sensitivity and resolution.

FINCA received in 2017 a five-year research infrastructure grant from the Academy of Finland to enable participation in ESO instrument projects, FINCA is participating on behalf of the Finnish community in two of the ELT instrument consortia, MOSAIC (optical and near-infrared multi-object spectrograph), and MICADO (near-infrared adaptive optics imager). FINCA is also participating in the NOT Transient Explorer (NTE), a new instrument for the NOT capable of simultaneous optical and near-infrared spectroscopy and imaging, with first light expected in 2022. As a followup to NTE participation, and to build a bridge toward involvement in ESO instrumentation, FINCA is also participating in a new instrument to the ESO 3.5-m New Technology Telescope (NTT), the Son Of X-Shooters (SOXS), a very similar instrument to the NTE, with first light expected in 2021. The calibration unit of SOXS is being built at the University of Turku. FINCA is going to apply for more instrumentation funding from the Academy in the 2019 call to strengthen the position of the Finnish community toward the ELT era starting mid-next decade.

Jari Kotilainen,

FINCA Director



2. Staff and Organization

FINCA staff (Turku, unless otherwise indicated)

Director :	Jari Kotilainen
Professor emeritus :	Mauri Valtonen
University Researchers :	Roberto De Propris Pasi Hakala Kari Nilsson
Academy Research Fellows	Talvikki Hovatta (Aalto/Turku, from 01.09.2018) Elina Lindfors (from 01.09.2018)
Special Researcher	Jari Kajava
Postdoctoral Researchers	Marco Berton (Aalto; from 1.9.2018) Ghassem Gozaliasl (Helsinki) Joachim Janz (Oulu) Karri Koljonen (Aalto) Hanindyo Kuncarayakti Ronald Läsker (until 31.8.2018) Suvendu Rakshit (from 15.12.2018) Clare Wethers (from 1.9.2018) Laura Zschaechner (Helsinki)

FINCA board

Members

Name	University
Anne Lähteenmäki	Aalto
Merja Tornikoski	Aalto
Jyrki Räisänen	Helsinki
Alexis Finoguenov	Helsinki
Juergen Schmidt	Oulu
Heikki Salo	Oulu
Kalle-Antti Suominen (Chair)	Turku
Seppo Mattila	Turku
Elina Lindfors (staff representative)	Turku

Deputy members

Name	University
Joni Tammi	Aalto
Tuomas Savolainen	Aalto
Karri Muinonen	Helsinki
Mika Juvela	Helsinki
Vitaly Neustroev	Oulu
Sebastien Comeron	Oulu
Harry Lehto	Turku
Juri Poutanen	Turku
Roberto De Propris (staff representative)	Turku

Figure 2.1: FINCA staff and students 2019, From left to right and clockwise: Jari Kotilainen, Roberto De Propris, Vandad Fallah Ramazani (student), Hanindyo Kuncarayakti, Suvendu Rakshit, Simona Paiano (visitor), Maria Stone (student), Chantal Baboraam (student), Kari Nilsson, Kalle Karhunen (student), Clare Wethers. Photo taken by Elina Lindfors (not shown).

3. Research

3.1 Main research areas

The research at FINCA concentrates on observational astronomy carried out using radio to γ-rays, multi-wavelength data from large ground-based and space telescopes. Especially, we make use of ESO's large ground-based facilities in the optical and infrared (the four 8m ESO Very Large Telescopes; VLT) and in (sub)millimetre (Atacama Large Millimeter Array; ALMA), together with the Nordic Optical Telescope (NOT) on La Palma, in the northern hemisphere. Our observational research is supplemented by modelling, computer simulations and theoretical work, that are essential in understanding the physics behind the observations. The present science topics at FINCA cover a large range in contemporary astronomy from observational cosmology, distant active galaxies, and galaxy formation and evolution, through properties of nearby galaxies, to supernovae and their progenitor stars, stellar activity and star formation in our own Galaxy. In 2018, our research were reported in XX refereed scientific articles, and some of them are highlighted below.

3.2 Research Highlights

3.2.1 Cosmology and Extragalactic Astrophysics

The Ultraviolet Upturn in Elliptical Galaxies Early-type galaxies show excess flux at short (vacuum UV) wavelengths compared to the expectations from a model that fits their optical-infrared colors. There is a broad consensus that the responsible sources are blue horizontal branch (core helium burning) stars, but the origin of these objects is unclear as they should not be present in a metal-rich stellar population at the age of early-type galaxies. A similar phenomenon may be responsible for the 'second parameter' in Galactic globular clusters, where the hot HB stars are known to be enhanced in helium content. The evolution of the UV color (as parameterized by $FUV - r$, where FUV is a 1550 Å band similar to that in GALEX satellite) provides clues to the origin of this UV bright population. We (a project led by **De Propris**) have used (Ali et al. 2018a,b,c) a combination of archival imaging from GALEX, UVOT and HST to explore the evolution of this colour as a function of redshift and to compare with models: our sample reaches to the luminosity level of L^* galaxies and therefore to more typical objects than the luminous brightest cluster galaxies that were observed in some previous studies (at lower redshifts). Our data (**Fig. 3.1**) are consistent with no significant evolution in color and scatter to $z = 0.55$ but in a $z = 0.68$ cluster we observe clear evidence of a rapid reddening in $FUV - r$. This is only consistent with a model where $\sim 10\%$ of the stellar population in early-type galaxies is enriched in helium at $\sim 42\%$ or above, about twice the cosmological value. From our knowledge of stellar evolution, we estimate that the stars were formed at least by $z \sim 4$ and were *in situ* at this epoch, implying the existence of galaxies with very large stellar masses at early times.

Extreme Faraday rotation revealed by ALMA

Talvikki Hovatta and collaborators studied the polarization of the nearest quasar 3C273 using ALMA at 1.3mm wavelength, corresponding to ~ 234 GHz frequency. These were the first full-polarization observations of the source with ALMA, and the first ever at the high frequency, where the polarization over the wide bandwidth of ALMA (224-242 GHz) could be studied in detail. They found the polarization position angle to have a dependence as a function of wavelength over the ALMA 1.3mm band, indicating that the polarization from the source is experiencing extreme Faraday rotation of 5×10^5rad/m^2. Moreover, they found that the fractional polarization increased as a function of wavelength, unexpected for any simple Faraday rotation models. These results indicate, that either the Faraday rotation is originating from plasma embedded within the jet itself (internal Faraday rotation), or that there are multiple Faraday-emitting components that are not spatially resolved with ALMA. In both cases, the magnetic field and/or electron density must be high to explain the extreme Faraday rotation. The results are accepted for publication in A&A. The study of 3C273 continues in 2019 with new ALMA Cycle 6 data that were taken in November 2018 at three different frequency bands of 140, 234, and 345 GHz.

Chandra centers for COSMOS X-ray galaxy groups: Differences in stellar properties between central dominant and offset brightest group galaxies

We present (**Gozaliasl** and collaborators) the results of a search for galaxy clusters and groups in the 2 square degree field of the COSMOS field using all available X-ray observations from the XMM-Newton and Chandra observatories (see Fig. 1). We reach an X-ray flux limit of 3×10^{-16} ergs cm^{-2} s^{-1} in 0.5–2 keV range, and identify 247 X-ray groups with $M_{200} = 8 \times 10^{12}$ to 3×10^{14} $M_\odot$ at a redshift range of $0.08 < z < 1.53$, using the multiband photometric redshift and the master spectroscopic redshift catalogues of the COSMOS. The X-ray centres of groups are determined using high-resolution Chandra imaging. We investigate the relations between the offset of the brightest group galaxies (BGGs) from halo X-ray centre and group properties and compare with predictions

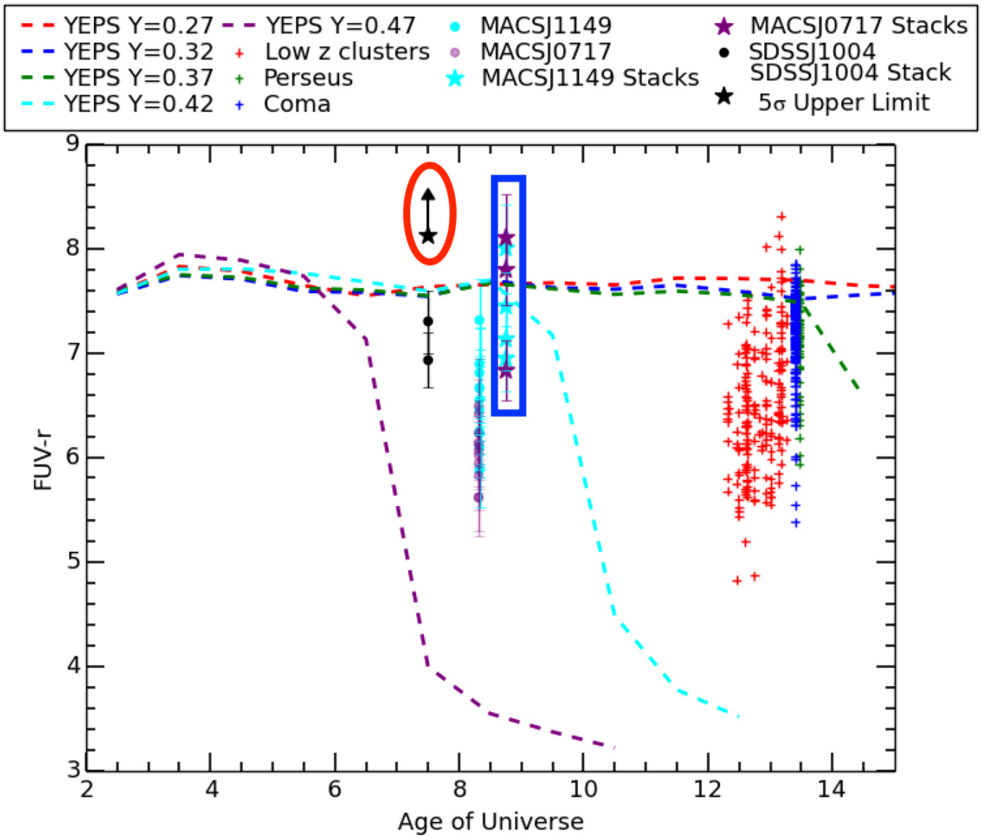


Figure 3.1: Evolution of the UV color with lookback time for red sequence galaxies in clusters to $z = 0.7$. At the highest redshift observed our data only allow us to derive an upper limit to the colour, which is significantly redder than at lower redshifts. The models shown assume $z_{form} = 4$ and solar metallicity and imply helium abundances in excess of 42%.

from semi-analytic models and hydrodynamical simulations. We find that BGG offset decreases with both increasing halo mass and decreasing redshift with no strong dependence on the X-ray flux and SNR. We show that the BGG offset decreases as a function of increasing magnitude gap with no considerable redshift dependent trend. The stellar mass of BGGs in observations extends over a wider dynamic range compared to model predictions. At $z < 0.5$, the central dominant BGGs become more massive than those with large offsets by up to 0.3dex, in agreement with model prediction. The observed and predicted lognormal scatter in the stellar mass of both low- and large-offset BGGs at fixed halo mass is 0.3dex .

Origin of ultra high energy cosmic neutrinos revealed for the first time

For the first time, astrophysicists (including FINCA members **Hovatta, Lindfors, Nilsson**) have localized the source of a cosmic neutrino originating outside the Milky Way. This was nominated to be a scientific breakthrough of the year 2018 by the Science magazine. It is highly likely that the neutrino comes from a blazar, an active black hole at the center of a distant galaxy in the Orion constellation. The neutrino signal from IceCube was combined with measurements from the Fermi-

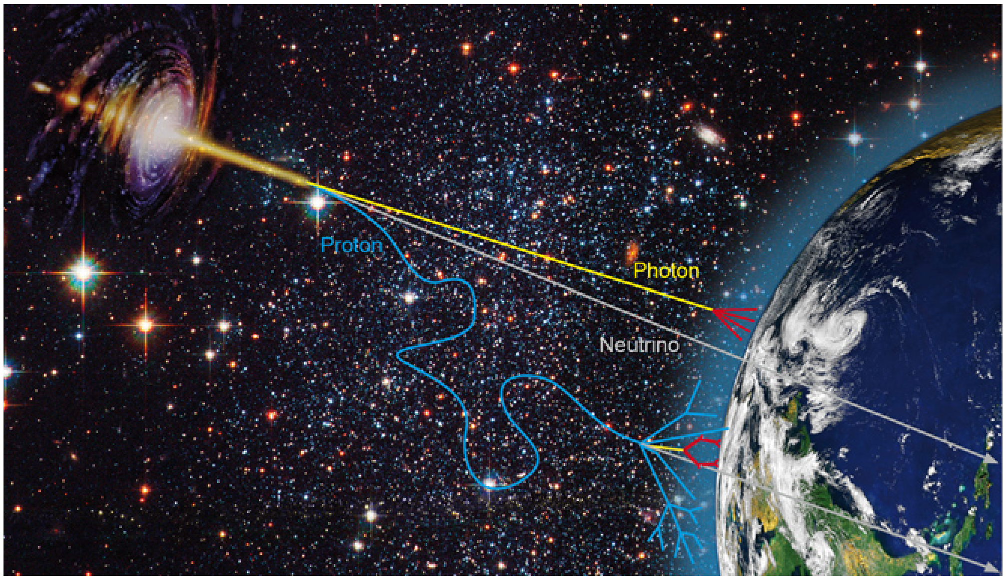


Figure 3.2: Cartoon version of the detection of high energy neutrinos from Cherenkov radiation of high energy cosmic ray particles interacting with the atmosphere

LAT and MAGIC telescopes together with other instruments. This multi-messenger observation was also able to provide a clue to an unsolved mystery: the origin of cosmic rays **(Fig. 3.2)**. The largest detector specialized in hunting the neutrinos is IceCube, which is located at the South Pole. It detects about 200 neutrinos per day, although most of them have low energy and are produced by cosmic rays interacting with the Earth's atmosphere. On 22 September 2017, IceCube detected a neutrino that was special: Its very high energy (roughly 290 teraelectronvolt) indicated that the particle might have originated from a distant celestial object. Scientists were also able to identify its incoming direction with high precision. The neutrino alert was promptly disseminated to numerous instruments in the hope that their observations might disclose the source of the neutrino. Fermi-LAT, a space observatory that conducts all-sky surveys, reported that the direction of the neutrino was in line with a known gamma-ray source in an active state: the blazar TXS 0506+056. What is more, MAGIC a 17-meter twin telescope that probes high energy gamma-rays from the ground, revealed that the radiation from the blazar reaches energies of at least 400 gigaelectronvolts. These findings, combined with the neutrino direction, make the blazar a likely candidate for the neutrino source. Since the birth of neutrinos is always linked to proton interactions, the observations help to solve an old mystery: The birthplace of cosmic radiation, discovered by the physicist Victor Hess in 1912. The cosmic neutrino tells us that the blazar is capable of accelerating protons to very high energies – and therefore may actually be one source of cosmic radiation.

Locating the Blazar zone

Blazars are active galactic nuclei (AGN) that host relativistic jets that are pointing very close to our line of sight. This results in their emission being highly beamed and Doppler boosted, making them bright and variable in all wavebands from radio to Very High Energy gamma-rays. The location of the blazar zone within the blazar jet has been a topic of decades long debate. The only wavelength at which we can spatially resolve the jet is radio, where the jet becomes optically thin several parsecs away from the black hole. It has been generally argued that the main blazar zone is located much closer to the black hole due to the fast variability we see, but also due to the lack of seed photons further out. In 2018 Elina Lindfors along with the MAGIC Collaboration and multiwavelength collaborators (including e.g. **Talvikki Hovatta** from FINCA and Merja Tornikoski and Anne Lähteenmäki from Metsähovi Radio Observatory) published results from two extensive multiwavelength campaigns on blazars. In these papers, data from radio to VHE gamma-rays was used to pinpoint the location of the blazar zone to the 43GHz VLBI core and possible solutions to the seed photon problem in these cases. FINCA researchers are also involved in the observing program that uses ESO and NOT telescopes to determine the unknown redshifts for blazars that are potentially interesting for the upcoming CTA Observatory.

IRAS20181-2244

Marco Berton and collaborators published the results of their observations of the host galaxy of a young active galactic nucleus (AGN), IRAS 20181-2244 (Berton et al., 2019, AJ, 157, 48). This galaxy, located at 727 Mpc from us (z = 0.185), has an extremely strong radio emission, comparable to that of AGN harboring a relativistic radio jet, but its infrared emission suggests that an intense star formation (up to 300 solar masses per year) can be responsible for most of the radio emission. The observations were carried out with in the near infrared using the 6.5m Baade telescope of the Las Campanas Observatory in Chile. The Ks-band image (see **Fig.3.3**) of the galaxy was modeled using a 2-dimensional fitting software, GALFIT. The analysis revealed that IRAS 20181-2244 has a disk host strongly affected by ongoing interaction with a second disk galaxy. We confirmed that the two objects are at the same distance, hence interacting, by means of spectroscopic observations performed with the Nordic Optical Telescope. The infrared color of the system confirmed that star formation is present, especially in a H II region located south-east of the AGN, and in a tidal tail likely formed in the interaction. However, we could not confirm the exceptionally high star formation rate found by previous observations, concluding that a relativistic jet must be present in this object to account for its radio emission. Furthermore, as observed in several AGN, we also concluded that the interaction between the two galaxies is possibly associated with the relativistic jet production, since it provides the additional source of gas for the central black hole that triggers the jet launching.

OJ287

Mauri Valtonen has continued the analysis of the OJ287 GR Centenary flare optical data. This is done in preparation for the next superflare in OJ287 on 30 July 2019. The accurate timing of the July 30 superflare is of fundamental importance to proving the no-hair theorem of black holes, and indirectly, proving the existence of black holes in General Relativity, as Valtonen has demonstrated with Achamveedu Gopakumar and Lankeswar Dey (Mumbai).

At the same time, the original theory by Lehto and Valtonen (ApJ 1996) of a secondary black hole impacting on the accretion disk of the primary black hole has been readjusted in the light of the GR flare data. It is shown that the density of the accretion disk is about a factor of two higher than in the original model which implies that the viscosity parameter alpha is 0.26 +- 0.05, instead of unity, as in the original model. The mass accretion rate is also about 20% lower than in the earlier model. A graduate student Sissi Enestam has been taking part in this work, together with Pauli Pihajoki (Helsinki) and Harry Lehto.

Valtonen has also studied the 1989 fade in OJ287 observed by Leo Takalo and associates **(Fig. 3.4)**. As Takalo et al. pointed out, the color of OJ287 changes dramatically at the minimum

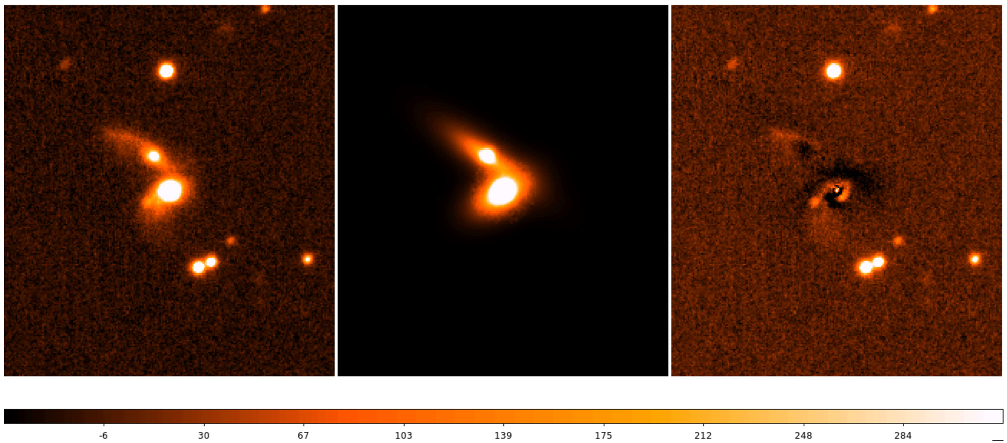


Figure 3.3: **Left:** Ks band image of IRAS 20181-2244 obtained with the 6.5m Baade telescope (North is up, East is left). The AGN IRAS 20181-2244 is the source in the middle of the image; **middle:** GALFIT model of the NLS1 and its companion. The 2-dimensional profile was reproduced using a Moffat PSF and a Sérsic profile with $n = 1$ for the AGN, while for the companion we used two Sérsic profiles ($n = 4$ for the bulge and $n = 1$ for the host); **right:** residuals of the GALFIT modeling. The tidal tail is visible in North-East direction, while an H II region is visible as a bright spot South-East of the AGN nucleus.

light in the manner expected, if the host galaxy makes a significant contribution to the total light output. The present work shows that the magnitude of the host is $V = 18.05 \pm 0.3$ mag. on this basis. However, because the diafragm of the photometry does not cover the possible outer component of the host, it could be even brighter than this, making it one of the brightest galaxies in the universe. With the accurately known central black hole mass, the host is placed at the upper end of the black hole mass vs. host galaxy correlation, in the region already populated by four other galaxies. In parallel, Kari Nilsson has analyzed data from several epochs of surface photometry of OJ287, obtained tother with Jari Kotilainen and others, which are in general agreement with the integrated photometry.

The radio jet in OJ287 shows large wobble in the time scale of years. Valtonen and Pihajoki (2013) presented a model of how this arises when the jet is viewed almost head-on. With Lankeswar Dey (Mumbai) and Pauli Pihajoki (Helsinki) Valtonen has improved the accretion disk model to include kinematic viscosity. They find that the inner disk precesses in a way which is closely linked to the spin direction of the primary black hole. Using the observations of the wobble, two models have been fitted to the data: (1) the model where the inner disk launches the jet, and (2) the model where the jet is launched from the black hole. The former model gives a better fit at this time. New observations have been scheduled, lead by Jose Gonzales, Granada, to obtained jet images at future epochs, using a global network of telescopes where ALMA is a key instrument. These observations will further constrain the models.

Galactic winds

In 2018, **Laura Zschaechner** and collaborators observed galactic winds with ESO facilities including Atacama Large Millimeter/submillimeter Array (ALMA), The Multi Unit Spectroscopic Explorer (MUSE), and the K-band Multi Object Spectrograph (KMOS). Galactic winds regulate

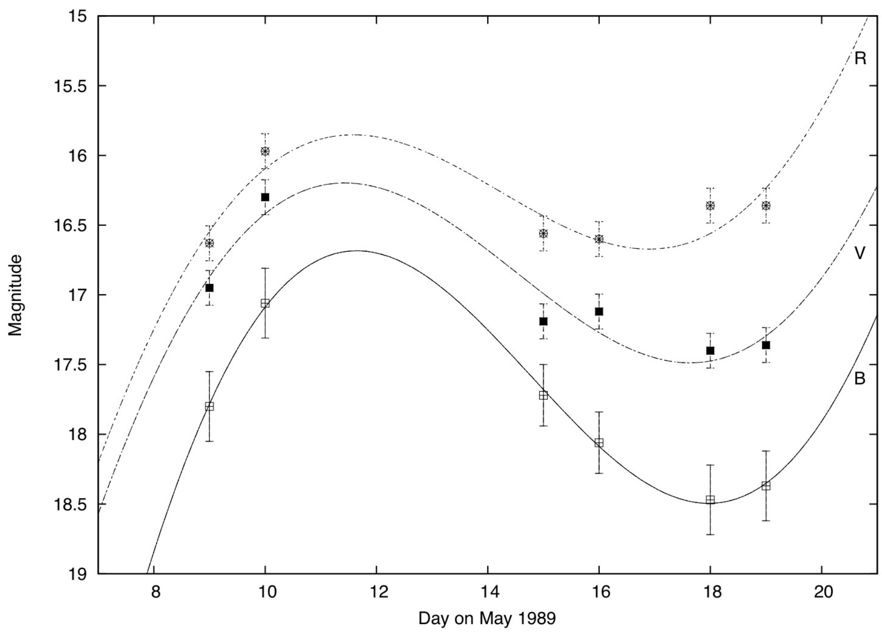


Figure 3.4: The 1989 fade of OJ287 observed by Leo Takalo et al.. The B, V and R channel observations at the Nordic Optical Telescope are shown by open squares, closed squares and crossed circles, respectively. In the AGN the the normal colors are B-V=0.57 and V-R=0.44, while an elliptical host galaxy at redshift z=0.3 of OJ287 should have colors B-V=1.43 and V-R=0.91. We see that during the fade the AGN + host color changes from a typical AGN to an almost typical host. Quantitatively, we determine the host magnitude to $V = 18.05 \pm 0.03$. The lines give an indication of the light curve at the three channels. The B-curve is closest to the original AGN light curve, while the V and R light curves are strongly influenced by the host.

feedback, quench star formation, limit the total mass of large galaxies, and eject enriched material into the Intergalactic medium. Only recently have facilities such as MUSE and ALMA made detailed, wide-field characterization of the ionized and molecular phases possible. In Zschaechner et al. (2018), Laura Zschaechner and collaborators presented Atacama Large Millimeter/submillimeter Array (ALMA) observations of 12CO(1-0) and 12CO(2-1) in the central 40” (680 pc) of the nuclear starburst galaxy NGC 253, including its molecular outflow. They measure the ratio of brightness temperature for CO(2-1)/CO(1-0) = r21, in the central starburst and outflow-related features. They discuss how r21 can be used to constrain the optical depth of the CO emission, which impacts the inferred mass of the outflow and consequently the molecular mass outflow rate. They find r21 1 throughout, consistent with a majority of the CO emission being optically-thick in the outflow, as it is in the starburst. This suggests that the molecular outflow mass is 3-6 times larger than the lower limit reported for optically thin CO emission from warm molecular gas. The implied molecular mass outflow rate is 25-50 solar masses per year, assuming that conversion factor for the outflowing gas is similar to our best estimates for the bulk of the starburst. This is a stunning factor of 9-19 times larger than the star formation rate in NGC 253. They also see tentative evidence for an extended, diffuse CO(2-1) component. Additional work is being done on higher resolution observations of CO(3-2) by FINCA visitor Nico Krieger from MPIA (FINCA host and co-I Laura Zschaechner). In a complementary study (Zschaechner et al. in prep), they explore the galactic wind in NGC 253 with using A-ranked time awared in ESO P102 (PI Laura Zschaechner). These MUSE observations allow for the first time, characterization of the physical conditions (clumping, shock strengths, metallicities, densities, and kinematics of molecular vs. ionized gas) of the wind in the most well-studied, resolved galactic-scale outflow to date. These data will provide crucial constraints for models describing galactic-scale feedback, which is a fundamental driver of galaxy evolution across all epochs of cosmic time.

Extra planar gas layers

Laura Zschaechner has continued work on extra-planar layers. Extra-planar (>200 pc above the midplane) layers are the interface between the intergalactic medium and star-forming disks. They are essential to understanding disk-halo flows and how gas is replenished to fuel future star formation (SF). Extra-planar material has been characterized extensively for all phases of the ISM - with the exception of molecular gas due to observational challenges. Molecular gas is of particular interest since it is thought to be closely-tied to SF - and yet a diffuse, extra-planar component would not be available for SF. Thus, there are strong implications for SF efficiency depending on the distribution of CO between the disk and halo at both low and high-z. In ALMA Cycle 6, Laura Zschaechner led a successful proposal to observe extra-planar and diffuse molecular gas in three galaxies, completing in essential parameter space to establish the relation between extra-planar molecular gas and star formation.

The shaping of dwarf galaxy populations in galaxy clusters

In Venhola et al. (2018), **Joachim Janz** and collaborators used the 26 square degrees of deep optical multi-band images of the Fornax galaxy cluster, obtained with the ESO VLT Survey Telescope, to derive various parameters of the observed (dwarf) galaxies, such as sizes, colours, and concentrations. With the help of these parameters 564 cluster member galaxies could be separated from the over 14000 detected galaxies. This new Fornax Deep Survey Dwarf Galaxy Catalog (FDSDC) capture the dwarf galaxy population down to a much lower mass than before (e.g., see Fig. 3.5, containing many dwarfs that had previously not been listed in the Fornax Cluster Catalog of Ferguson (1989). Our team continued to analyse the data in order to put constraints on the environmental processes shaping the dwarf galaxy populations in galaxy clusters (Venhola et al. 2019, A&A accepted). The observed variations of the parameters as a function of cluster-centric distance, which was used as a proxy for the local environment and the time of in-fall into the cluster, were compared to those expected from transformations of galaxies via stripping of their internal gas by the ram pressure caused by the hot cluster gas or, alternatively, via harassment, i.e. the combined effects of the gravitational pull experienced by a galaxy during fast close encounters with other galaxies in the cluster and by tidal forces due to the cluster potential itself. A novelty is the finding that more massive ($\log M_*/M_\odot > 8.8$) dwarf galaxies behave differently than less massive ones ($\log M_*/M_\odot < 8.8$): when considering galaxies in mass bins, we found that low-mass dwarfs are redder when they have lower surface brightness and vice versa for more massive dwarfs. The trend is found to be consistent with passively fading stellar populations after the quenching of star formation through ram pressure stripping for the low-mass dwarfs. The massive dwarfs, on the other hand, may experience a combination of harassment and non-instantaneous ram pressure stripping allowing for prolonged star formation in the galaxy centres.

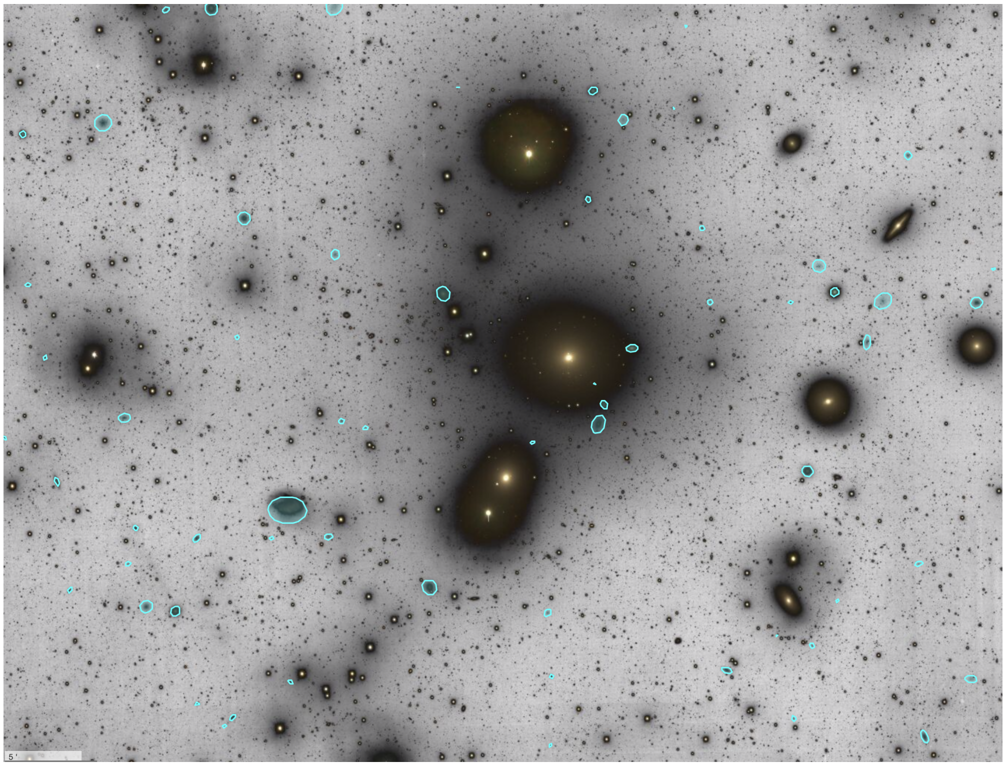


Figure 3.5: Deep image of the central part of the Fornax cluster with NGC 1399 (faint levels are displayed as inverted grey scales, while in brighter areas the images in the g, r, and i filters are shown as an RGB composite, part of the > 7500 Megapixel image of the entire cluster). Dwarf galaxies identified as cluster members by Venhola et al. (2018) are highlighted with cyan ellipses.

Barlenses are secularly-evolved structures

In Laurikainen et al. (2018), **Joachim Janz** and colleagues carried out a joint analysis of the photometry and stellar populations of barlenses in the CALIFA survey. Barlenses are round central components associated with bars. In fact, it is theoretically predicted that boxy-peanut bar components, often seen in barred edge-on galaxies, manifest themselves as barlenses when the galaxy is seen in a more face-on orientation. The prove that these central roundish components are associated with bars and formed secularly, as opposed to classical bulges, will be significant, since this highlights the importance of bars for galaxy evolution and possibly puts constraints on the hierarchical structure formation in the Universe. We found that a quarter of the galaxies in the CALIFA sample (1064 galaxies) have either boxy-peanut bar components or barlenses. Multi-component decompositions of the spatial light distribution of those galaxies with barlenses, taking the barlenses into account as separate components, leave at most 10% of the light for possible classical bulge components. Furthermore, the first joint analysis of such decompositions and maps of stellar population characteristics from integrated field spectroscopy, which is presented in this study, yielded further evidence for the observed central components being barlenses associated with the bars: their stellar ages and metallicities show similar distributions when compared to the bars.

Our team was awarded observing time with MUSE on ESO's VLT to verify this picture by observing certain features in the kinematics of the stars in galaxies with barlenses, which are predicted by simulations.

3.2.2 Stellar Astrophysics

Accretion flow/jet connection in black hole X-ray binaries

Accreting black holes are responsible for producing the fastest, most powerful outflows of matter in the Universe. The formation process of powerful jets close to black holes is poorly understood, and the conditions leading to jet formation are currently hotly debated. Due to their fast evolutionary timescales, X-ray binaries are ideal targets to study the jet formation process. This requires observing outbursting X-ray binaries simultaneously across the electromagnetic spectrum from radio up to X-rays.

The radio/X-ray correlation is one of the most important pieces of observational evidence of the connection between the accretion flow and the jet in accreting compact objects, i.e. that the increase in the mass accretion rate to the compact object during an outburst event (resulting in an increase of the X-ray emission) results in the increase of mass loading to the jet (subsequently resulting in an increase of the radio emission). It has been shown, that the same correlation is present also in active galactic nuclei given that the jet properties scale with the black hole mass. However, a growing number of X-ray binaries seem to present deviations from the universal radio/X-ray correlation and the origin of these outliers are still very much debated. In previous studies, the X-ray bolometric luminosity used in the radio/X-ray correlation has been estimated using a narrow, soft X-ray band. **Karri Koljonen** et al. (2019; ApJ, 871, 26) presented results on how estimating the X-ray bolometric luminosity using a much wider band that takes into account the full X-ray spectral shape impacts the radio/X-ray correlation. They found that all sources that reach high enough luminosity change their correlation slopes from the universal slope to a much steeper one. In addition, sources in the steeper radio/X-ray track show a distinct cutoff in the high-energy X-ray spectrum at tens of keV **(Fig. 3.6)**. These results suggest that the accretion flow presents a morphological change at a certain critical luminosity during the outburst rise from radiatively inefficient to radiatively efficient flow that is in turn more efficient in cooling the hot accretion flow producing the hard X-ray emission. This change could also affect the jet launching properties in these systems.

Observations and modeling of jet emission in black hole X-ray binaries

Karri Koljonen and collaborators presented optical and infrared observations of black hole X-ray binaries Swift J1357.2-0933 (Russell et al. 2018; ApJ, 852, 90) and MAXI J1535-571 (Baglio et al. 2019; ApJ, 867, 114). These sources show an optical and near-infrared spectrum that is consistent with an emission likely arising from a jet. In Swift J1357.2-0933, the evolving spectrum appears to be due to the evolution of a jet spectral break, i.e. the break frequency between optically thin and thick part of the jet synchrotron spectrum, that is shifting from the infrared to the optical and back through the observing period from 2012 to 2017. Swift J1357.2-0933 is a valuable source to study black hole jet physics at very low accretion rates and it is possibly the only source in which the optical jet properties can be regularly monitored during quiescence. On the other hand, MAXI J1535-571 was observed with VLT/VISIR during its outburst period in 2017/2018 and was found to have a surprisingly high flux density of approximately 100 mJy making it one of the brightest X-ray binary known in the mid-infrared so far. In addition, Baglio et al. (2019) presented the

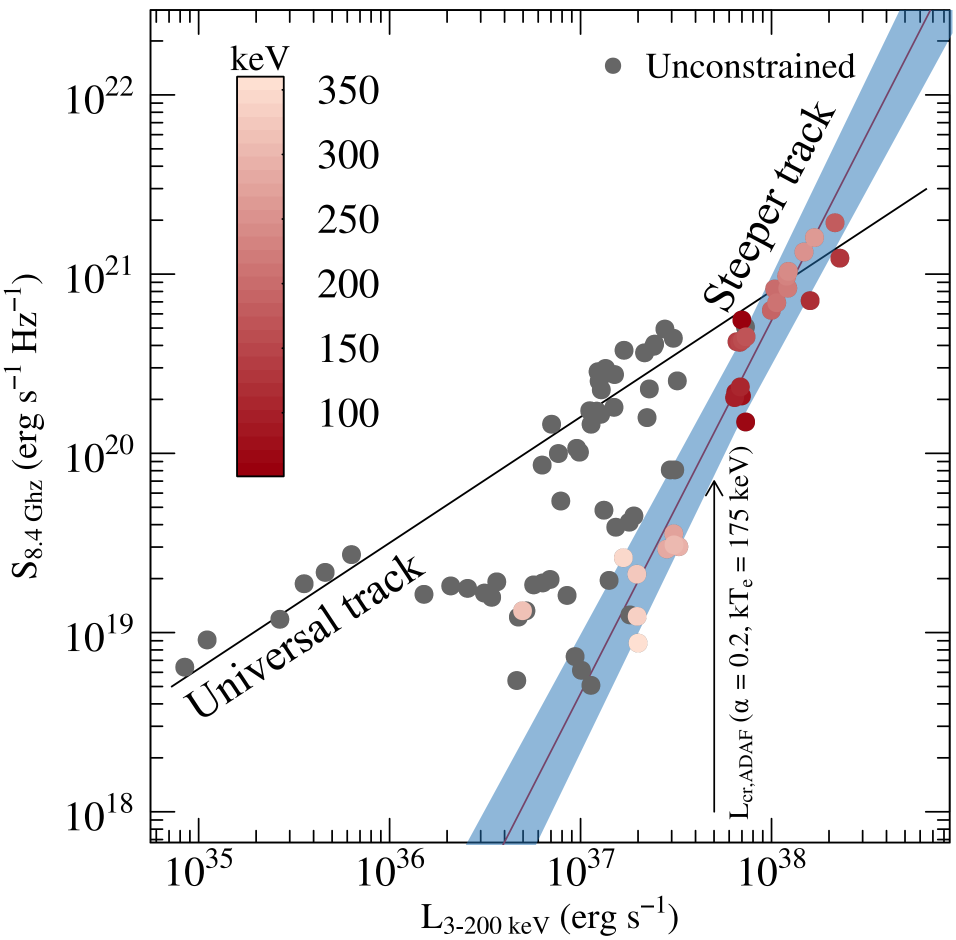


Figure 3.6: Radio/X-ray correlation of six X-ray binaries with the cutoff energy of the hard X-ray spectrum colored as a hue of red depending on the energy and gray if it is unconstrained. The sources show a measurable cutoff when they are aligned in the steeper track (red line). A critical luminosity for an efficiency change in the accretion disk for one pair of parameters suitable for GX 339–4 is shown as an arrow which coincides with the source changing from the universal track to the steeper track.

first mid-infrared variability study of a black hole X-ray binary on minute timescales, where the lightcurve properties were found to be similar to that expected from the internal shock jet model. These results represent an excellent case of multiwavelength jet spectral studies and demonstrate how rich, time-resolved multiwavelength data of X-ray binaries over accretion state transitions can help in refining models of the accretion flow/jet connection and jet launching in these systems.

Furthermore, in Peault et al. (2019; MNRAS, 482, 2447), Koljonen and collaborators fitted an internal shock model for five observational epochs during the 2011 outburst of MAXI J1836-194. Their model was able to produce the observed shift of the jet break in the spectral energy distributions by varying the jet velocity. In addition, they showed that the full evolution of the jet spectrum throughout the outburst could be fitted with varying only two parameters: the jet velocity and the jet power. Obtaining reasonable jet powers at all epochs required very small jet inclinations, which confirms that MAXI J1836-194 could be a microblazar and explains the compact jet dominance up to the optical wavelengths. Future tests of the model against other black hole X-ray binaries data will help to establish whether the inferred evolution of the jet velocity during the outburst can be generalized to other objects. These studies require multiwavelength monitoring throughout an outburst with good coverage not only in radio and X-rays but also in the optical, infrared, and submillimeter bands.

Mass loss of massive stars and their final fate as supernovae

Supernovae come in various appearances. Some show strong hydrogen lines in the spectrum, indicating that the photosphere is hydrogen-rich. Some others, show very weak or even no hydrogen, which is an indication that the outer hydrogen-rich layer of the exploding star has been stripped away. It is generally believed that the initial mass and metal abundance of the star influence the evolution, mass stripping, and terminal supernova type. Stars that are more massive and metal-rich have stronger stellar winds, blasting away significant amounts of material from the surface. Therefore, the expectation is that the supernovae that are hydrogen-rich came from stars with lower mass and metallicity, compared to those that manage to remove all the hydrogen. **Hanindyo Kuncarayakti** and collaborators used the surrounding stellar populations around supernovae to derive their ages and initial metallicities. As the age is effectively stellar lifetime, it can be converted into initial mass knowing that the length of a star's lifetime is mainly governed by its birth mass. Employing integral field spectroscopy using an array of VLT instruments (VIMOS, MUSE, and SINFONI), the team found no difference in metallicity among distinct supernova types, while there is initial mass overlap between hydrogen-rich and hydrogen-poor supernovae. This means that within a same range of mass and metallicity, some stars manage to shed their hydrogen envelope while some others do not. One possible explanation would be there is another mechanism at play in removing the envelope; this is proposed to be close binary interaction where a companion star disrupts the outer layers of the evolved primary star. (Kuncarayakti et al. 2018, A&A, 613, 35) Where this envelope mass goes, is another question. In a single star, the materials are expected to be blown away as relatively steady, high-velocity stellar winds, while in a binary system the companion star may accrete some of the material, and influence how the circumstellar material (CSM) is distributed around the system. Type-Ic supernovae, that are characterised by lack of hydrogen and helium, are thought to be the products of highly stripped stars. However, there has not been evidence of the presence of nearby CSM in a supernova Ic. SN 2017dio, a type-Ic supernova, was found to be strongly interacting with a nearby CSM containing hydrogen and helium. This is the first evidence that some stripped stars may still retain parts of their blown envelope nearby, and argues that steady winds cannot produce such phenomenon. It was proposed that binary interactions, or pre-supernova eruptions, may be important in removing the outer hydrogen and helium layers, while keeping the stripped material in close vicinity of the exploding star. (Kuncarayakti et al. 2018, ApJ, 854, L14) The work on supernova environments continued in 2018 with the approval of two VLT programmes using the MUSE integral field spectrograph to observe supernova host galaxies (PI: Kuncarayakti). In ESO periods 100 and 101, the programmes were awarded 95 hours and 99 hours of VLT time, respectively.

4. Instrument Development

The Son of X-Shooter (SOXS) design finalized

SOXS, the new instrument for the 3.6-m NTT telescope in ESO La Silla Observatory, Chile, has reached a new milestone in 2018 by passing the Final Design Review (FDR). This is on-track with the plan of instrument commissioning in late 2020. SOXS will first replace SOFI at one of the two NTT Nasmyth platforms, and when normal operation starts by early 2021 it is expected to be the main instrument at the NTT. As SOXS will have optical-infrared spectroscopic coverage (350-2000 nm, at 4500 resolution), its capabilities are expected to blanket the EFOSC2 spectrograph currently attached at the other Nasmyth platform. As such, SOXS is expected to be the workhorse for NTT and will be optimised for observations of transient and variable sources. With the FDR achievement, the next working phase of instrument manufacture, assembly, integration, and tests (MAIT) commences. Having been tasked with building the SOXS Calibration Unit, FINCA continues to contribute on this front with Kuncarayakti as the Work Package Manager. The construction works are to be carried out within the University of Turku campus, in Quantum building, in collaboration with the university workshop and local optomechanics industries. (Schipani et al. 2018, Proceedings SPIE, 10702, 107020F)

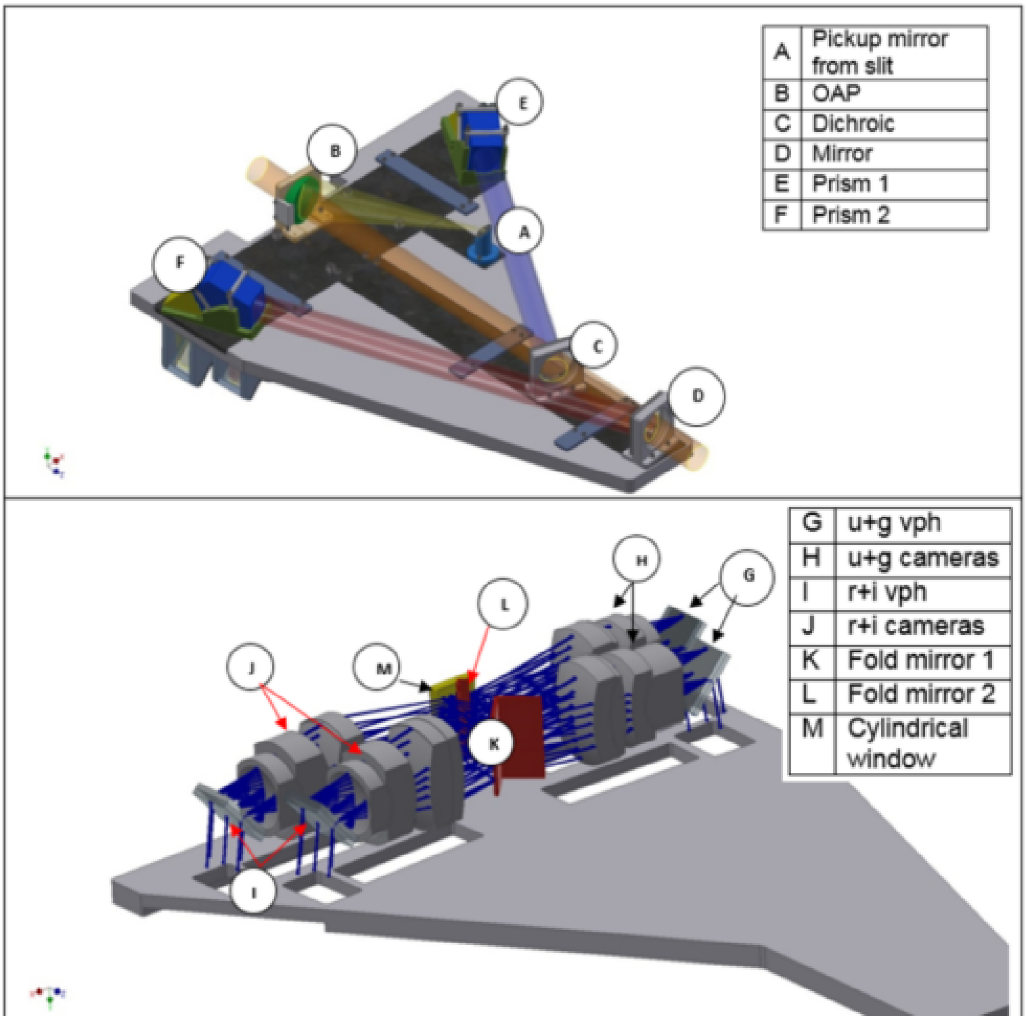
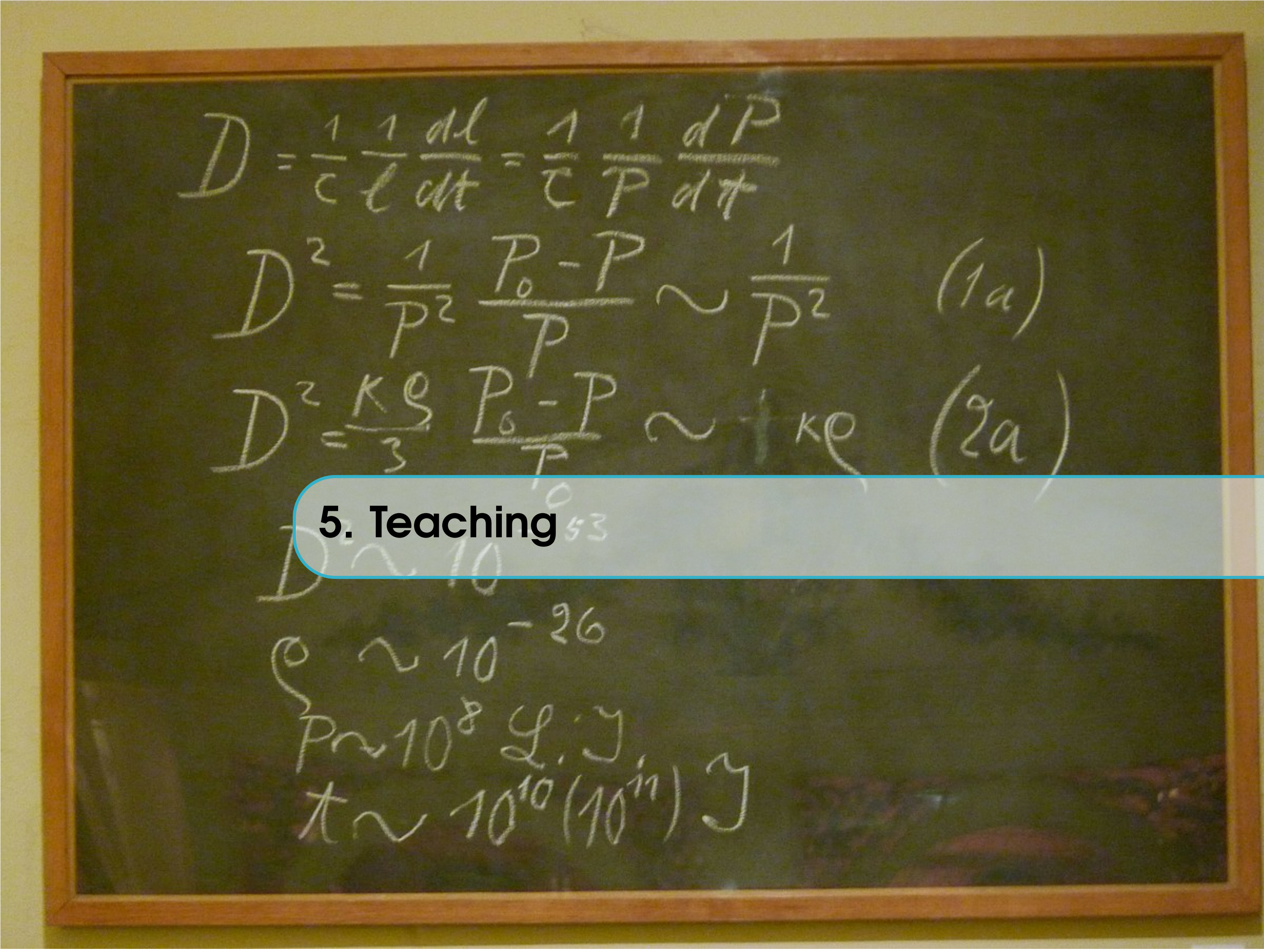


Figure 4.1: Schematic of SOXS on the ESO 3.6m



5. Teaching

5.1 Lectured courses

Basic level - in Finnish

Teacher	Course	Credits	Location
Talvikki Hovatta	Introductory Astronomy (Radio)	5	Turku
Jari Kotilainen	Evolution of the Universe...	6	Turku

Intermediate level - in Finnish or English

Advanced level - in English

M. Berton	The Tenth NEON Observing School	-	Asiago
Roberto De Propris	Galaxies and Cosmology	6	Turku
Talvikki Hovatta	TÄHT7032 Active Galactic Nuclei	6	Turku
Talvikki Hovatta	Space Instrumentation (Gamma)	5	Aalto
K. Koljonen	Space Instrumentation	5	Aalto
Jari Kotilainen	TÄHT7032 Active Galactic Nuclei	6	Turku
H. Kuncarayakti	NOT Observing School	6	Turku

5.2 Completed theses

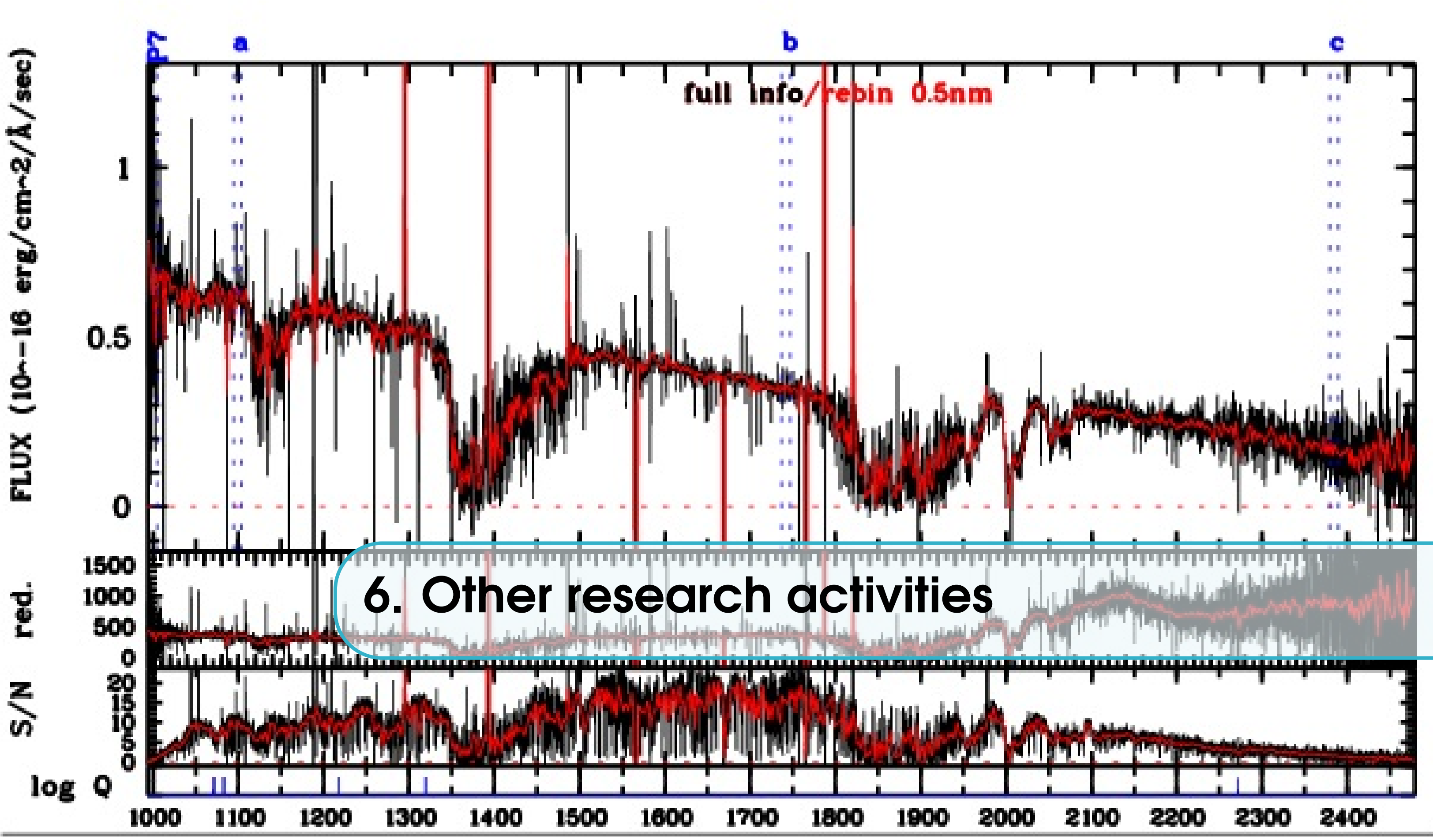
MSc theses

F. Gabrielli, *[O III] line properties in flat-spectrum radio quasars*, University of Padova, Italy, supervisor: Marco Berton
Suei Hei (Dexter) Hon, *“Structural properties of fossil group ellipticals”*, University of Turku, supervisor: Roberto De Propris

PhD theses

S. Ali, "*"The Ultraviolet Upturn in Elliptical Galaxies"*, University of Bristol, UK, co-supervisor: Roberto De Propris.
A. Olguin-Iglesias, ”*“The connection between jets and host galaxies of radio loud AGN: Blazars vs Narrow-line Seyfert 1s”*, INAOE, Mexico, co-supervisor: Jari Kotilainen
R. Ramphul, ”*Characterising star forming and luminous infrared galaxies with the South African Large Telescope (SALT))*, University of Cape Town, South Africa, pre-examiner: Jari Kotilainen

6. Other research activities



Memberships in conference SOC/LOC and other committees

J. Kotilainen	Finnish delegate in ESO Council
T. Hovatta	Finland's ESO Users' Committee representative
	President of the Finnish Astronomical Society
	Member of the European VLBI Network Programme Committee
	Member of the CTA Consortium
	Member of the SOC for the XIV Finnish-Russian Radio Astronomy Symposium, held on Sep 5-7, 2018 at Science Centre Tuorla, Finland
	Member of the SOC for the HAP workshop – Monitoring the non-thermal Universe, held on Sep 18-23, 2018 in Cochem, Germany
E. Lindfors	Member of the Collaboration and Executive Boards of the MAGIC Collaboration
	Multiwavelength Coordinator of the MAGIC Collaboration
	Member of the Consortium Board of CTA Consortium
L. Zschaechner	Linking the Milky Way and Nearby Galaxies: The ISM and Star Formation from Cold Cores to kpc Scales 3-7 June 2019 Lead organizer of LOC, member of SOC

Conference presentations

R. De Propris	"Evolution of the Ultraviolet Upturn" (poster) in *Challenges in Panchromatic Galaxy Modelling with New Generation Facilities*, Osaka, Japan, November 2018
H. Kuncarayakti	Physics Days 2018, 21-23 Mar, Turku, "The progenitors and environments of stripped-envelope supernovae", oral
	EWASS 2018, 2-7 Apr, Liverpool, "A type-Ic supernova interacting with a hydrogen-rich circumstellar medium", poster
	Shocking Supernovae, 27 May-1 Jun, Stockholm, "SN 2017dio: A type-Ic SN showing early interactions with H-rich circumstellar medium" oral
	ePESSTO Meeting, 21-23 Jul, Rome, "SN 2017dio: A type-Ic SN showing early interactions with H-rich circumstellar medium", oral
J. Kajava	EUCLID CalWG meeting, November 7 - 8, ESTEC/Leiden, Netherlands, oral presentation about DQCT
E. Lindfors	European Week of Astronomy and Space Science, 3 – 6 April 2018, Liverpool, oral: Cherenkov Telescope Array - A Sensitive Probe of the Extreme Universe
	European Week of Astronomy and Space Science, 3 – 6 April 2018, Liverpool, oral: Probing high-energy acceleration processes in S5 0716+714 using combined Fermi-LAT and MAGIC observations
	IAU Symposium 342 –Perseus in Sicily: from black hole to cluster outskirts, 2018 May 13-18, Noto, Sicily, Italy, Invited Talk: "Observations of AGNs and clusters with CTA"
T. Hovatta	T. Hovatta The XIV Finnish-Russian Radio Astronomy Symposium, 5.-7.9.2018, Tuorla, Finland. ALMA view of the nearest quasar 3C273 (oral)
	TCSM 10th Anniversary Seminar, 13.12.2018, Turku, Finland. How are relativistic jets and academic careers accelerated? (invited)
G. Gozaliasl	Euclid Consortium 2018 meeting, 11-14 June, Bonn, Germany
	COSMOS 2018 meeting, 28-30 June, Copenhagen, Denmark
	Euclid OU-VIS meeting, IAP, Paris, France, 12–14 November 2018
	Euclid Developer workshop 5, 06-09 November, Groningen, Netherlands
J. Kotilainen	Revisiting Narrow-line Seyfert 1 galaxies and their place in the Universe, 10.-13.4.2018, Padova, Italy, (oral): The host galaxies of radio-loud vs. gamma-loud Narrow-Line Seyfert 1s
	Astronomers' Days 2018, 28.-30.5.2018, Kuusamo, Finland, oral: A catastrophic failure to build a galaxy around a supermassive black hole at z=4

Other talks

R. De Propris	Evolution of the UV upturn Yonsei University, Seoul
J. Kotilainen	Host galaxies of radio-loud vs gamma-loud NLSy1s , Tokyo, Japan
J. Kajava	Outflows from the black hole binary V404 Cyg Turku, Finland
H. Kuncarayakti	Study of supernova progenitors and environments through integral field spectroscopy, Stockholm

Research Visits

R. De Propris	Yonsei University, November 2018
T. Hovatta	California Institute of Technology, USA, 27.8.-3.9.2018
E. Lindfors	Instituto de Astrofisica de Canarias, 13.-20 February, 2018
	CTA Consortium Meeting, 24-28 September, Berlin, Germany
	MAGIC Collaboration Meeting, 18-23 November, Rome, Italy
H. Kuncaratakti	SOXS Progress Meeting, INAF, Napoli, 21-24 Feb,
	SOXS FDR Meeting, INAF, Milano, 18-20 Jul
	Korea Astronomy and Space Science Institute (KASI), 21-27 Oct
J. Kotilainen	NAOJ Tokyo, Japan, 11.-19.9.2018
K. Koljonen	- INAF-OAR, 16.2.-25.2
	New York University Abu Dhabi, 27.11.-6.12

Hosted visitors

Federico Bernardini, INAF-OAR – Host: K. Koljonen

Michael West, Lowell Observatory, USA – Host: R. De Propris

Michael Rich, UCLA – Host: R. De Propris

Pavel Kroupa, Univ. Bonn, Germany – Host: J. Kotilainen
Tereza Jerabkova, ESO Garching, Germany – Host: J. Kotilainen
Petri Väisänen, SAAO, South Africa – Host: J. Kotilainen
Moses Mogotsi, SAAO, South Africa – Host: J. Kotilainen

N. Krieger, MPIA Heidelberg – Host: L. Zschaechner

J. D. Lyman, University of Warwick, UK – Host: H. Kuncarayakti
A. Nyholm, Stockholm University, Sweden – Host: H. Kuncarayakti
G. Folatelli, Universidad de La Plata, Argentina – Host: H. Kuncarayakti

7. Publications

Refereed publications by FINCA staff 2018:

Aartsen M et al. (including **Lindfors, Nilsson**) *Multimessenger observations of a flaring blazar coincident with high-energy neutrino IceCube-170922A*, 2018, *Science*, 361, 1378

Abeysekara AU et al. (including **Hovatta, Lindfors, Nilsson**) *Periastron Observations of TeV Gamma-Ray Emission from a Binary System with a 50-year Period*, 2018, ApJ, 867, L19

Acciari VA et al. (including **Lindfors, Nilsson**) *Detection of persistent VHE gamma-ray emission from PKS 1510-089 by the MAGIC telescopes during low states between 2012 and 2017*, 2018, A&A, 619, A159

Acciari VA et al. (including **Lindfors, Nilsson**) *Constraining very-high-energy and optical emission from FRB 121102 with the MAGIC telescopes*, 2018, MNRAS, 481, 2479

Acciari VA et al. (including **Lindfors, Nilsson**) *Constraining very-high-energy and optical emission from FRB 121102 with the MAGIC telescopes*, 2018, Physics of the Dark Universe, 22, 38

Ahnen ML et al. (including **Nilsson**) *Indirect dark matter searches in the dwarf satellite galaxy Ursa Major II with the MAGIC telescopes*, 2018, JCAP, 3, A9

Ahnen ML et al. (including **Lindfors, Nilsson**) *Constraints on particle acceleration in SS433/W50 from MAGIC and H.E.S.S. observations*, 2018, A&A, 612, A14

Ahnen ML et al. (including **Hovatta, Lindfors, Nilsson**) *Detection of the blazar S4 0954+65 at very-high-energy with the MAGIC telescopes during an exceptionally high optical state*, 2018, A&A, 617, A30

Ahnen ML et al. (including **Hovatta, Lindfors, Nilsson**) *Multi-wavelength characterization of the blazar S5 0716+714 during an unprecedented outburst phase*, 2018, A&A, 619, A45

Ahnen ML et al. (including **Lindfors, Nilsson**) *Limits on the flux of tau neutrinos from 1 PeV to 3 EeV with the MAGIC telescopes*, 2018, APh, 102, 77

Ahnen ML et al. (including **Hovatta, Lindfors, Nilsson**) *Extreme HBL behavior of Markarian 501 during 2012*, 2018, A&A, 620, A181

Ali SS, Bremer MN, Phillipps S, **De Propris R** *UV SEDs of early-type cluster galaxies: a new look at the UV upturn*, 2018, MNRAS, 476, 1010

Ali SS, Bremer MN, Phillipps S, **De Propris R** *Evolution of the UV upturn in cluster galaxies: Abell 1689*, 2018, MNRAS, 478, 541

Ali SS, Bremer MN, Phillipps S, **De Propris R** *The rise and fall of the UV upturn: z = 0.3, 0.55, and 0.7*, 2018, MNRAS, 480, 2236

Ansoldi S et al. (including **Lindfors, Nilsson**) *The Blazar TXS 0506+056 Associated with a High-energy Neutrino: Insights into Extragalactic Jets and Cosmic-Ray Acceleration*, 2018, ApJ, 863, L10

Ansoldi S et al. (including **Lindfors, Nilsson**) *Gamma-ray flaring activity of NGC1275 in 2016-2017 measured by MAGIC*, 2018, A&A, 617, A91

Ansoldi S et al. (including **Hovatta, Lindfors, Nilsson**) *The broad-band properties of the intermediate synchrotron peaked BL Lac S2 0109+22 from radio to VHE gamma-rays*, 2018,MNRAS, 480, 879

Baglio MC, Russell DM, Casella P et al. (including **Koljonen KI**) *A Wildly Flickering Jet in the Black Hole X-Ray Binary MAXI J1535-571*, 2018, ApJ, 867, A114

Banerjee DPK, Hsiao EY, Diamond T et al. (including **Kuncarayakti H**) *Unraveling the Infrared Transient VVV-WIT-06: The Case for the Origin as a Classical Nova*, 2018, ApJ, 867, A99

Blinov D, Pavlidou V, Papadakis I et al. (including **Hovatta**) *RoboPol: connection between optical polarization plane rotations and gamma-ray flares in blazars*, 2018, MNRAS, 474, 1296

de Blok WJG, Walter F, Ferguson AMN et al. (including **Zschaechner LK**) *A High-resolution Mosaic of the Neutral Hydrogen in the M81 Triplet*, 2018, ApJ, 865, A26

Boselli A, Fossati M, Consolandi G et al. (including **Kuncarayakti H**) *A Virgo Environmental Survey Tracing Ionised Gas Emission (VESTIGE). IV. A tail of ionised gas in the merger remnant NGC4424*, 2018, MNRAS, 480, 3424

Bremer MN, Phillipps S, Kelvin LS et al., (including **De Propris**) *Galaxy and Mass Assembly (GAMA): Morphological transformation of galaxies across the green valley*, 2018, MNRAS, 476, 12

Britzen S, Fendt C, Witzel G et al. (including **Nilsson**) *OJ287: deciphering the 'Rosetta stone of blazars*, 2018, MNRAS, 478, 3199

Cai YZ, Pastorello A, Fraser M et al. (including **Kuncarayakti H**) *AT 2017be - a new member of the class of intermediate-luminosity red transient*, 2018, MNRAS, 480, 3424

Chen T.-W., Inserra C., Fraser M. et al. (including **Berton, Kuncarayakti**) *SN 2017ens: The Metamorphosis of a Luminous Broadlined Type Ic Supernova into an SN IIn*, 2018, ApJ, 867, L31

Cohen MD, Aller HD, Aller MF et al. (including **Hovatta**) *Reversals in the Direction of Polarization Rotation in OJ 287*, 2018, ApJ, 862, A1

De Propris R, Bremer MN, Phillipps S *Luminosity functions of cluster galaxies. The near-ultraviolet luminosity function at* $< z > \sim 0.05$, 2018, A&A, 618, A180

Dey L, **Valtonen M**, Gopakumar A et al. (including **Nilsson**), *Authenticating the Presence of a Relativistic Massive Black Hole Binary in OJ 287 Using Its General Relativity Centenary Flare: Improved Orbital Parameters*, 2018, ApJ, 866, A11

Ferre-Mateu A, Forbes DA, Romanowski AJ, **Janz J**, Dixon C *On the formation mechanisms of compact elliptical galaxies*, 2018, MNRAS, 473, 1819

Foster F, Moriya TJ, Moreira JC et al. (including **Kuncarayakti H**) *The delay of shock breakout due to circumstellar material evident in most type II supernovae.*, 2018, Nature Astronomy, 2, 808

Galbany L, Anderson JP, Sanchez SF et al. (including **Kuncarayakti H**) *PISCO: The PMAS/PPak Integral-field Supernova Hosts Compilation*, 2018, ApJ, 855, A107

Galbany L, Collett TE, Mendez-Abreu J, Sanchez SF, Anderson JP, **Kuncarayakti H**) *Serendipitous discovery of a strong-lensed galaxy in integral field spectroscopy from MUSE*, 2018, MNRAS, 479, 262

Goyal A, Stawarz L, Zola S et al. (including **Hovatta, Nilsson**) *Stochastic Modeling of Multiwavelength Variability of the Classical BL Lac Object OJ 287 on Timescales Ranging from Decades to Hours*, 2018, ApJ, 863, A175

Gozaliasl G, Finoguenov A, Khosroshahi H et al. *Brightest group galaxies - II: the relative contribution of BGGs to the total baryon content of groups at z < 1.3* , 2018, MNRAS, 475, 2787

Hakala P, Kajava J) *Variable polarisation and Doppler tomography of PSR J1023+0038 - Evidence for the magnetic propeller during flaring?*, 2018, MNRAS, 474, 3297

Homan D, **Hovatta T**, Kovalev Y, Lister M, Pushkarev A, Savolainen T *Constraints on Particles and Fields from Full Stokes Observations of AGN*, 2018, Galaxies, 6, 17

Jaron F, Massi M, Kiehlmann S, **Hovatta T** *Simultaneous long-term monitoring of LS I +61°303 by OVRO and Fermi-LAT*, 2018, MNRAS, 478, 440

Järvelä E, Lähteenmäki A., **Berton M** *Near-infrared morphologies of the host galaxies of narrow-line Seyfert 1 galaxies*, 2018, A&A, 619, A69

Kelvin LS, Bremer MN, Phillipps S et al. (including **De Propris R**) *UGalaxy and Mass Assembly (GAMA): variation in galaxy structure across the green valley*, 2018, MNRAS, 477, 4116

Kettlety T, Helsing S, Phillipps S et al., (including **De Propris**) *Galaxy and mass assembly (GAMA): the consistency of GAMA and WISE derived mass-to-light ratios*, 2018, MNRAS, 473, 776

Kidger M, Zola S, **Valtonen M** et al., *Far-infrared photometry of OJ 287 with the Herschel Space Observatory*, 2018, A&A, 610, A74

Koljonen KI, Maccarone T, McCullough ML et al. *The hypersoft state of Cygnus X-3. A key to jet quenching in X-ray binaries*, 2018, A&A, 612, A27

Kool EC, Ryder S, Kankare E et al., (including **Kotilainen**), *First results from GeMS/GSAOI for project SUNBIRD: Supernovae UNmasked By Infra-Red Detection*, 2018, MNRAS, 473, 5641

Krühler T, Fraser M, Leloudas G et al. (including **Kuncarayakti H**) *The supermassive black hole coincident with the luminous transient ASASSN-15lh*, 2018, A&A, 610, A14

Kuncarayakti H, Maeda K, Ashall CJ et al. *SN 2017dio: A Type-Ic Supernova Exploding in a Hydrogen-rich Circumstellar Medium*, 2018, ApJ, 854, A14

Kuncarayakti H, Anderson JP, Galbany L et al. *Constraints on core-collapse supernova progenitors from explosion site integral field spectroscopy*, 2018, A&A, 613, A35

Laurikainen E, Salo H, Laine J, **Janz J** *Barlenses in the CALIFA survey: Combining photometric and stellar population analyses*, 2018, A&A, 618, A34

Leroy AC, Bolatto AD, Ostriker EC et al. (including **Zschaechner LK**) *Forming Super Star Clusters in the Central Starburst of NGC 253*, 2018, ApJ, 869, A126

Liodakis I, **Hovatta T**, Huppenkothen D, Kiehlmann S, Max-Moerbeck W, Readhead ACS *Constraining the Limiting Brightness Temperature and Doppler Factors for the Largest Sample of Radio-bright Blazars*, 2018, MNRAS, 478, 440

Lisker T, Viyajaraghavan R, **Janz J**, Gallagher JS, Engler C, Urich L *The Active Assembly of the Virgo Cluster: Indications for Recent Group Infall From Early-type Dwarf Galaxies*, 2018, ApJ, 865, A40

Longinotti AL, Vega O, Krongold Y et al., (including **Kotilainen**), *Early Science with the Large Millimeter Telescope: An Energy-driven Wind Revealed by Massive Molecular and Fast X-Ray Outflows in the Seyfert Galaxy IRAS 17020+4544*, 2018, ApJ, 867, L11

Mattila S, Pérez-Torres M, Efstathiou A et al., (including **Kotilainen**), *A dust-enshrouded tidal disruption event with a resolved radio jet in a galaxy merger*, 2018, *Science*, 361, 482

Michalowski MJ, Gentile G, Krühler T et al. (including **Kuncarayakti H**) *Relativistic supernova 2009bb exploded close to an atomic gas cloud*, 2018, A&A, 618, A104

Mylläri A, **Valtonen M**, Pasechnik A, Mikkola S *Stability of hierarchical triples - I. Dependence on inner eccentricity and inclination*, 2018, MNRAS, 476, 830

Nilsson K, Lindfors E, Takalo L et al. (including **Hovatta**) *Long-term optical monitoring of TeV emitting blazars. I. Data analysis*, 2018, A&A, 620, A185

Pandya V, Romanowsky AJ, Laine S et al. (including **Läsker R**) *The Stellar Populations of Two Ultra-diffuse Galaxies from Optical and Near-infrared Photometry*, 2018, ApJ, 858, A29

Pilipenko SV, Kovalev YY, Adrianov AS et al. (including **Hovatta**) *The high brightness temperature of B0529+483 revealed by RadioAstron and implications for interstellar scattering*, 2018, MNRAS, 474, 3523

Pittori C, Lucarelli F, Verrecchia F et al. (including **Nilsson**) *The Bright γ-ray Flare of 3C 279 in 2015 June: AGILE Detection and Multifrequency Follow-up Observations*, 2018, ApJ, 856, A99

Richter B, Winkel P, Wakker BP et al. (including **Zschaechner LK**) *Circumgalactic Gas at Its Extreme: Tidal Gas Streams around the Whale Galaxy NGC 4631 Explored with HST/COS*, 2018, ApJ, 868, A112

Russell DM, Qasim AA, Bernardini F, Plotkin RM, Lewis R, **Koljonen KI**, Yang YJ *Optical Precursors to Black Hole X-Ray Binary Outbursts: An Evolving Synchrotron Jet Spectrum in Swift J1357.2-0933*, 2018, ApJ, 852, A90

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