Turun yliopisto
University of Turku

FINCA
Finnish Centre for Astronomy with ESO

Finnish Centre for Astronomy with ESO

Annual Report

2014

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Cover illustration : Atacama Large Millimeter/submillimeter Array (ALMA) on Chajnantor plateau, Chile at 5000 meters altitude. The array consists of 73 radio telescopes observing at submillimeter wavelengths. Picture credit: ESO/B. Tafreshi (twanight.org).

FINNISH CENTRE FOR ASTRONOMY WITH ESO, ANNUAL REPORT 2014

EDITOR: KARI NILSSON, FINCA, (KANI@UTU.FI)

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APRIL 2015

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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 15 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 2014 marked the 5th 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 the FINCA staff. A Scientific Advisory Board (SAB) consisting of seven foreign members, oversees the functioning of FINCA.

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 magnetic activity, star formation and exoplanets 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 96 refereed scientific articles, and some of them are highlighted in the Research section of this Annual Report.

Our researcher training activities in 2014 focused on one hand in supervision of PhD and MSc students in the participating universities, and on the other hand in starting and developing hands-on teaching of advanced observing, data reduction and analysis methods in observational astronomy as national collaboration. These courses made use of both remote observing with the NOT, and ESO archival data.

To mark the occasion of 10 years of Finnish membership in ESO, FINCA organized in Turku in October 2014 a two-day meeting of the ESO Council, the highest governing body of ESO. The meeting was attended by ∼40 delegates and ESO management.

In 2015, the major step forward at ESO, with implications for research at FINCA, will be the start of construction of the European Extremely Large Telescope (E-ELT), a 39 m diameter giant for infrared and optical astronomy, to start operations in about 10 years time. Now is the time to start adjusting one's research goals for the enormous leap forward in sensitivity and resolution brought by the E-ELT!

FINCA continues in an active role to facilitate Finnish industry to participate as sub-contractors in building the E-ELT and its instrumentation. FINCA is involved in discussions for the participation of the Finnish community in one of the E-ELT instrument consortia, the ELT-MOS (optical and near-infrared multi-object spectroscopy), that will start operations towards the end of 2015. 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 in 2018.

Jari Kotilainen
FINCA Director

2. Staff and organization

FINCA staff (Turku, unless otherwise indicated)

Director : Jari Kotilainen

Professor emeritus : Mauri Valtonen

University Researchers :
Andrei Berdyugin
Roberto De Propris
Thomas Hackman (Helsinki; until 30.6.2014)
Pasi Hakala
Heidi Korhonen
Eija Laurikainen (Oulu)
Seppo Mattila
Kari Nilsson
Vilppu Piirola

Postdoctoral researchers
Sébastien Comerón (Oulu)
Erkki Kankare (until 31.3.2014)
Jonathan León-Tavares (Turku + Aalto; until 15.4.2014)
Elina Lindfors (until 31.5.2014)
Andrew Mason
Elina Nieppola (Aalto)
Sergey Tsygankov (Oulu; until 31.8.2014)

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doc. Pasi Hakala (Turku; staff rep.)	doc. Seppo Mattila (Turku; staff rep.)

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Prof. Janet Drew	University of Hertfordshire, United Kingdom
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Dr. Hans Kjeldsen	Aarhus University, Denmark
Prof. Johan Knapen	Instituto de Astrofisica de Canarias, Spain
Dr. Bruno Leibundgut	European Southern Observatory, Germany

3. Research

3.1 Main research areas

The research at FINCA concentrates on observational astronomy carried out using radio to gamma-rays multi-wavelength data from large ground-based and space telescopes. The most commonly used methods are optical and infrared imaging, spectroscopy and polarimetry. Especially, we make good 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 studies of the structure, kinematics and stellar population properties of nearby galaxies, to supernovae, their progenitor stars, and use as probes of their host galaxies, binary stars, stellar magnetic activity, interstellar medium, star formation and exoplanets in our own Galaxy. In 2014, our research were reported in 96 refereed scientific articles, and some of them are highlighted below.

3.2 Research highlights

3.2.1 Galaxy evolution and cosmology

Concurrent growth of thick discs and central mass concentrations

The stars in local universe galaxy discs can be divided into the thin and the thick disc components according to their vertical light distribution. While we see that the thin discs are still forming, the ubiquitous thick discs seem to be old. Their formation mechanism remains a mystery. Some authors suggest that they are relics of the early and turbulent formation processes of galaxies. Others argue that thick discs formed via secular evolution over billions of years. Because thick discs can make up to 50% of the stellar baryonic mass of a galaxy, unveiling how they form is a key element in understanding how galaxies themselves form. **Sébastien Comerón**, **Eija Laurikainen**, and collaborators have used S4G imaging to learn more on the thick disc formation issue.

The S4G is made of 3.6μm and 4.5μm images taken using the Spitzer Space Telescope. The survey includes 2352 galaxies selected to have a radial velocity vradio$<$3000 km/s, to have an AB magnitude m$_{3.6,corr}$<15.5 mag, to have a diameter D$>$1 arcmin, and to be away from the Galactic plane (|b|$>$30°).

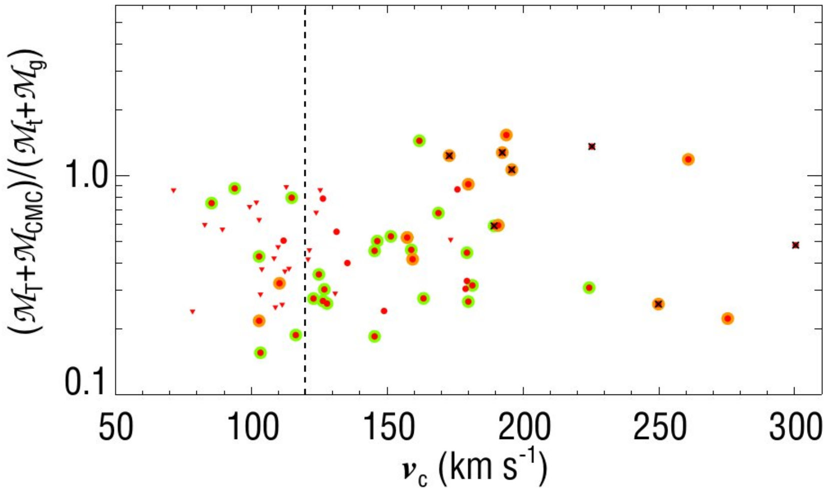

Figure 3.1: Mass ratio between the hot and the cold component masses as a function of the galaxy circular velocity, which is a proxy for its mass. Different symbols indicate different CMC types.

The authors decomposed images of 69 edge-on galaxies into their main components, namely the thin disc, the thick disc, and the central mass concentration (CMC). They converted the light of these components into mass. They found that the relative mass fraction of the thick disc decreases as the galaxy mass increases (Fig. 3.1). The opposite trend is seen for the CMCs. They also obtained gas disc masses from archival radio observations.

Altogether, the mass of the thick disc + the CMC (dynamically hot components) compared to that of the thin disc + the gas disc (dynamically cold components) varies little with the galaxy mass. This issuggestive of the hot components sharing a common origin.

The authors propose the following formation scenario for galaxies. Young disc galaxies are highly turbulent and clumpy because of intense star formation, accretion energy input, and gravitational instabilities. A direct consequence of that is that the gas disc out of which early galaxy components are born must be thick. The stellar components born out of this thick gas disc of these early galaxies would also be thick. In the most massive galaxies, the clumps would have lost energy through dynamical friction and would have coalesced into a CMC. In lower-mass galaxies, all the clumps would have ended dissolving into the thick disc. The thin disc would have formed later from a much thinner disc with a reduced star formation rate.

Close pairs and the galaxy merger rate

Within the GAMA survey, a large multi-wavelength study of 250,000 galaxies in the local universe, **Roberto De Propris** and his co-workers have been studying the galaxy merger rate via the fraction of objects in close pairs. Using the large GAMA dataset, they have measured how the merger fraction depends on luminosity and mass, its evolution with redshift (for the brightest galaxies) and whether mergers are dry (gas-poor) or wet (gas-rich). They have estimated the fraction of dry and wet mergers as a function of luminosity, as well as these fraction of bulge vs. disk dominated mergers. Finally, they explored how the merger process affects the star formation, morphology and activity of galaxies and the environments of merging pairs (Robotham et al. 2014, De Propris et al. 2014). A future paper (Davies et al., 2014, in preparation) will explore the direct effect of pairs on star formation. Together with a group in Taiwan, they have also created a new catalog of K-band selected mergers and measured the merger rate and its dependence on stellar mass.

Post-starburst galaxies

Roberto De Propris and his co-workers have used a catalog of post-starburst galaxies in the SDSS together with archival photometry from GALEX, Spitzer and WISE to analyse their stellar populations and understand the mechanism behind the onset and subsequent cessation of star formation. For a subset of these galaxies they were also able to recover deep X-ray images as well as archival HST imaging. From these they argued that there is evidence of feedback, proceeding from the inside-out, but no relation to QSO activity causing such feedback.

The Galactic Globular Cluster Catalog

This catalog is part of a Ph.D. thesis by U. Ghent, (2014), which **Roberto De Propris** co-supervised and consists of a homogeneous catalog of integrated photometry for a large fraction of the Globular cluster system of our Galaxy, to be used as a template for stellar population studies. This includes imaging from 1m class telescopes and integrated spectroscopy with VLT. They have published the description of the data and the colour-luminosity relations and submitted two of the analysis papers on King models and on the use of HB stars as tracers of multiple populations, with future work on the multi-wavelength spectral energy distributions, the colour-magnitude diagrams and the integrated spectra.

Low-redshift quasars in the Sloan Digital Sky Survey (SDSS) Stripe 82

Jari Kotilainen and collaborators have studied the properties of the host galaxies and environments of low-redshift ($z < 0.5$) quasars, based on a large and homogeneous data set of objects derived from the Sloan Digital Sky Survey (SDSS) Stripe 82 region, that is up to 2 mag deeper than standard SDSS images (Fig. 3.2). This study, comprising of $\sim$400 quasars and a similar number of inactive galaxies, closely matched in luminosity and redshift, is larger by a factor of $\sim$5 than any previous study of quasar host galaxies at low redshift undertaken either from ground or from space.

They were able to detect the host galaxy in more than 3/4 of the quasars and found that quasar hosts are preferentially very luminous galaxies. The morphology of the host galaxies turned out to be more complex than found in previous studies. Quasars are hosted in a variety of galaxies, from pure ellipticals to complex/composite morphologies, combining spheroids, discs, lenses and halos. The black hole mass of the quasar, estimated from the spectral properties of the nuclei, is poorly correlated with the total luminosity of the host galaxy. However, taking into account only the bulge component, a significant correlation was found between the black hole mass and the bulge luminosity of the host.

They also compared the environments of the resolved quasars to those of the inactive galaxies. The environmental overdensities were studied by measuring the number density of galaxies within projected distances up to 1 Mpc. The density of the quasar environments is comparable to that of inactive galaxies, both classes showing significant excess compared to background galaxy density at distances < 400 kpc. The galaxy number density does not significantly depend on redshift, quasar or host galaxy luminosity, black hole mass or radio loudness. This suggests that the fuelling and triggering of

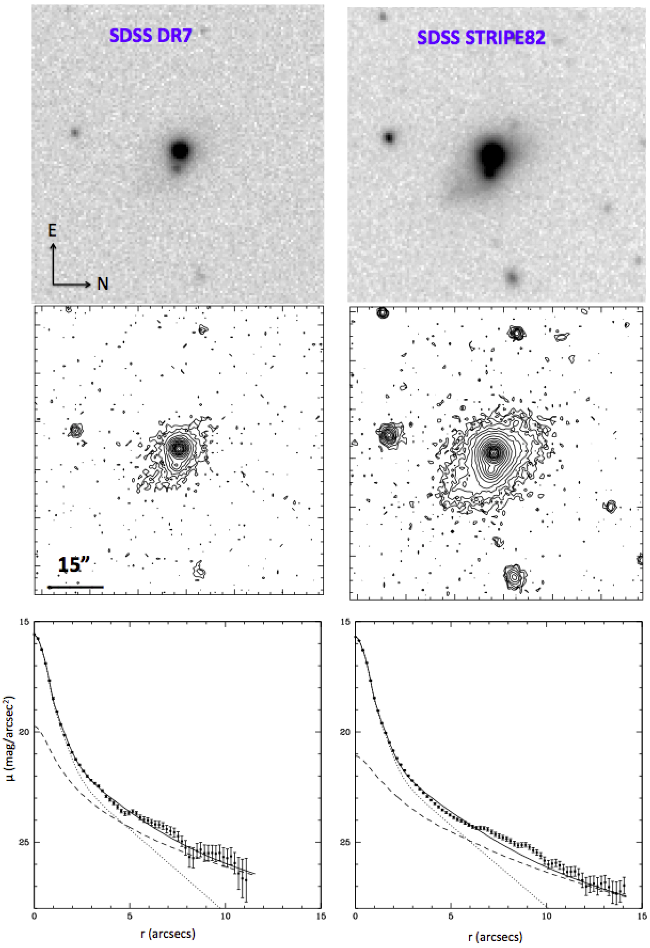

Figure 3.2: An example showing the difference in depth between the i-band images in SDSS DR7 (left-hand panels) and Stripe 82 (right-hand panels) for the region around the quasar SDSS J023922.87-000119.5. The Stripe 82 image is a combination of 35 individual images. Top panels show the i-band greyscale images; central panels show the contour plots, and the bottom panels show the radial luminosity profiles together with the best fit (solid line) consisting of the unresolved nucleus (dotted line) and the host galaxy (Sersic law model; dashed line).

nuclear activity depends only weakly on the local environment, and the quasar phase may be a short-lived common phase in the life cycle of all massive galaxies.

The Host galaxy of the γ-ray Narrow-line Seyfert 1 galaxy 1H 0323+342

The *Fermi* γ-ray satellite has detected emission from a wide variety of astrophysical objects, 60% of which are strongly beamed AGN, leading to the remark that the most common type of sources in the γ-ray sky are AGN whose relativistic jet points towards the Earth (i.e. blazars). Blazar nuclei have been systematically found to be hosted by giant elliptical galaxies. The latter has served as observational ground for the paradigm that powerful relativistic jets can almost exclusively be launched from massive elliptical galaxies, which in turn links the presence of prominent relativistic jets to the latest stages of galaxy evolution.

However, the recent detection of bright and variable γ-ray emission from narrow-line Seyfert type 1 galaxies (NLSy1) by *Fermi* , casts doubts on the exclusive relation between powerful jets and early-type galaxies. Unlike γ-ray blazars, NLSy1 have always been found to be hosted by late-type galaxies where the prevalence of pseudo bulges has been suggested. The small black hole masses inferred from their broad-emission lines (FWHM <2000 km/s), their voracious appetite indicated by the high accretion rates close to the Eddington limit, together with their demography seen only in the local universe ($z < 0.8$) and their compact radio structures, have served as arguments to

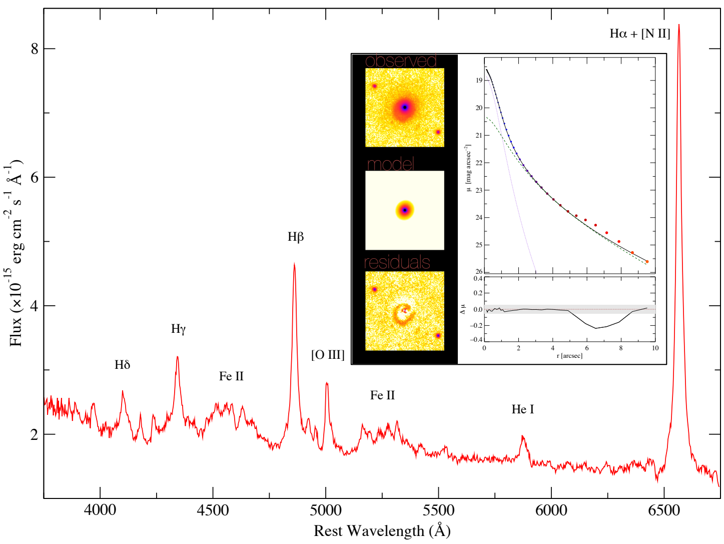

Figure 3.3: Rest frame optical spectrum of 1H 0323+342 taken with the GHAO on 17th September 2012. The inset panel shows the 2D surface brightness profile decomposition of 1H 0323+342 in the *J*-band.

believe that NLSy1 might be AGN in an early phase of evolution.

Motivated by the possibility that 1H 0323+342, the closest NLSy1 detected by Fermi (z=0.061), could be an outstanding case where a prominent relativistic jet uses a late-type galaxy as a launch pad, **Jonathan León-Tavares**, **Jari Kotilainen** and their co-workers obtained BRJK$_s$ images at the Nordic Optical Telescope (NOT) to perform a systematic structural modeling of the host galaxy. They also undertook a contemporaneous spectroscopy to obtain a virial estimate of the 1H 0323+342 black hole mass.

Based on two-dimensional surface-brightness modeling (Fig. 3.3), they found that the best model fit is a combination of a nuclear component and a Sérsic profile ($n \sim 2.8$). However, the presence of a disk component (with a small bulge $n \sim 1.2$) also remains a possibility and cannot be ruled out with the present data.

Although at first glance a spiral-arm-like structure is revealed in our images (see the inset in Fig. 3.3), a 2D Fourier analysis of the imagery suggests that this structure corresponds to an asymmetric ring, likely associated with a recent violent dynamical interaction. This scenario is supported by the timescales of galaxy interaction and radio structures derived earlier.

Therefore, it is likely that 1H 0323+342 is hosted by a galaxy that may have experienced an interaction in the recent past, as suggested by the presence of the ring structure identified in this work. If this picture holds, it would imply that a recently triggered AGN, might be able to launch (and collimate) fully developed relativistic outflows at an early evolutionary stage. This in turn would become an essential input to theoretical models for the formation of relativistic jets, AGN feedback and galaxy evolution. Then, it is evident that the attempt to characterize the host galaxy in other γ-ray NLSy1 is essential to understand the nature and evolutionary stage of this new class of γ-ray emitters.

Star formation history of Centaurus A

Mauri Valtonen together with Sarah Bird (Tuorla Obs.), Chris Flynn (Swinburne Univ., Australia and FINCA) and William Harris (McMaster Univ., Canada) has studied the formation history of the earliest stars in the galaxy Centaurus A. It is a well known active galaxy, with strong radio emission, and optically it is distinguished by a wide band of dust in its central plane which cuts through the otherwise elliptical body. In this study stars belonging to the galaxy were identified far from the centre, up to 70 kpc from it. The ages of the stars were determined by photometry. The observations were carried out with VLT using the VIMOS instrument in 2009 and in 2011. These were compared with the HST observations closer to the galaxy centre.

From previous studies of two other systems, the Andromeda spiral galaxy and the elliptical galaxy NGC3379, it was expected that at such distances only old relic stars would exist, with younger stars being more concentrated to the centre. Surprisingly, it was found that Centaurus A has a normal mixture of old relic stars and younger stars all the way to this distance. If there is a change to relic stars only, it must happen further out than 70 kpc in Centaurus A. However, it becomes very difficult to identify Centaurus A stars at greater distances since the stars become very rare so far from the centre.

As an explanation of the surprising property of the star distribution in Centaurus A it was suggested that the star mixture at large distances from the galaxy centre is not primordial, but a result of a merger of two major galaxies in this system billions of years ago. The merger would have distributed younger stars from the galactic central region to its extreme edges by dynamical ejections. The peculiar structure of Centaurus A has been previously interpreted as such a merger, and the activity of the galaxy may be related to the same event. We would need studies of star histories in more galaxies to confirm this finding.

Optically selected BL Lacertae objects

Kari Nilsson continued the study of a sample of 182 optically selected BL Lacs from the SSDS together with his collaborators J. Heidt and D. Kügler from Heidelberg, Germany. The main aim of this study is to test the effectiveness of the optical survey presented by Collinge et al. (2005) in discerning the BL Lacs from other types of targets. Continuing from the polarization study presented in paper I, the second paper presents data of the variability, broadband SEDs and host galaxies of the sample targets in addition to new optical spectra of 27 targets. While the final conclusion will be presented in paper III, it was already clear from the present study that optical selection works very well in picking up the BL Lacs.

Very High Energy gamma-rays from Active Galactic Nuclei

Very High Energy gamma-rays (VHE, $>$100 GeV) can be observed indirectly from the ground using Imaging Air Cherenkov Telescopes. FINCA researcers **Elina Lindfors** and **Kari Nilsson** are members of international MAGIC Collaboration, operating two 17 meter IACTs located at La Palma. Blazars are the most numerous sources of the VHE sky. Among more than fifty blazars detected at these extreme energies, only three belong to the subclass of Flat Spectrum Radio Quasars (FSRQs): PKS 1510-089, PKS 1222+216 and 3C 279. The detection of FSRQs in the VHE range is challenging, mainly because of their steep soft spectra in the GeV-TeV regime. MAGIC has observed and detected all FSRQs known to be VHE emitters up to now and found that they exhibit

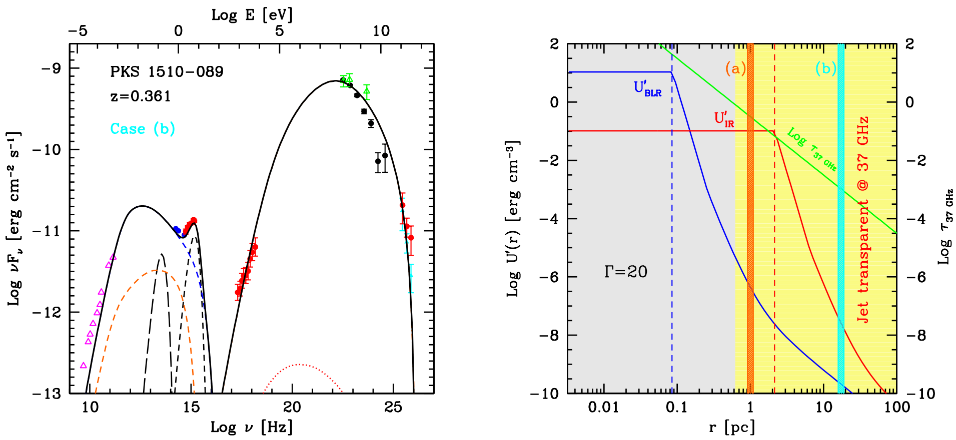

Figure 3.4: *Left*: The radiative environment of PKS 1510-089 evaluated by taking into account the coincident timing of radio and gamma-ray events in the multiwavelength light curves, placing the emission region to several parsecs from central engine. *Right*: The spectral energy distribution modelled with the external Compton emission with the seed photons provided by the slow sheath of the jet.

very different behavior.

In 2014, two detailed multiwavelength studies of VHE gamma-ray emitting FSRQs were finalized with Elina Lindfors being the corresponding author of both papers. These papers collected data from MAGIC, Fermi-LAT gamma-ray satellite, Swift X-ray satellite and ground based optical and radio observatories, including data from the Tuorla blazar monitoring program and Metsähovi Radio Telescope. Both campaigns took place during a moderate activity in optical and GeV gamma-ray band. Therefore it was not surprising that detailed study of the multiwavelength data did show several similarities in the behaviour of the two sources in optical, X-ray and GeV gamma-ray band. However, there were significant differences in the radio and VHE gamma-ray behaviour. While 3C 279 did not show any activity in radio or VHE bands, in PKS 1510-089 (Fig. 3.4) the VHE gamma-ray emission was simultaneous with a flare at 37 GHz and the ejection of a new component from the 43 GHz VLBA core. These results are consistent with the scenario where the VHE gamma-rays are emitted far from the central black hole. In the latter paper we performed a first detailed calculation, taking into account the constraints from radio data, of the radiative environment at such distances.

3.2.2 Interstellar matter and Stellar astrophysics

Ultrasensitive polarization measurements

One of the main goals of the long-term polarimetric campaigns by **Vilppu Piirola** and **Andrei Berdyugin** and their co-workers (Svetlana Berdyugina, Jeffrey Kuhn, Colin Aspin and Enric Palle) are studies of 'hot Jupiter' type exoplanets by ultra-sensitive ($e_p < 10^{-5}$) linear polarization measurements over the planetary orbital cycle with DIPOL-2 (see Chapter 4). Phase-locked variations in the observed star+planet flux, arising from the light scattered by the exoplanet atmosphere, are modeled to reveal the orbital parameters (inclination, eccentricity, orientation) and the physical properties of

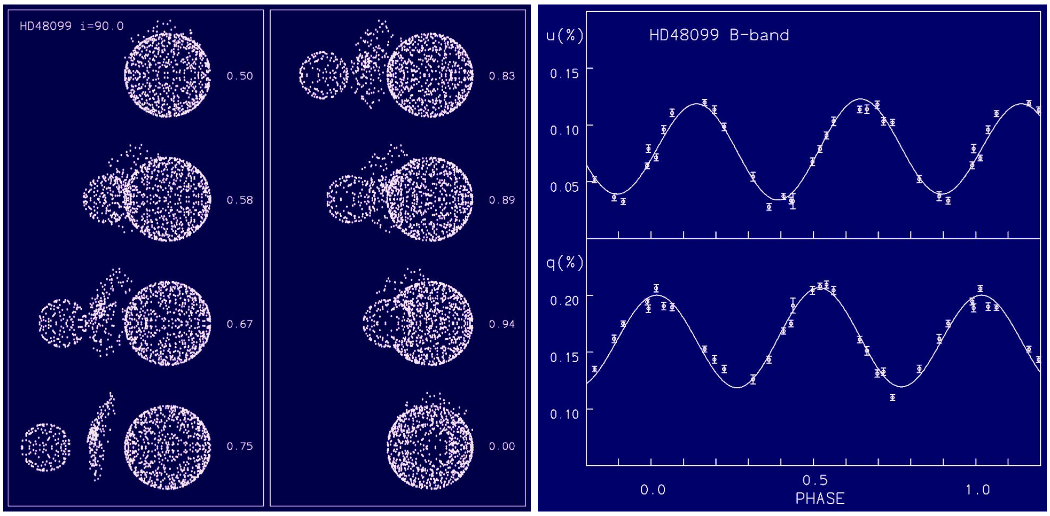

Figure 3.5: *Left*; Illustration of a 3D scattering model of a plasma cloud, formed by a colliding wind outflow in the massive O5.5+O9 binary HD48099. Side view of the model at different orbital phases is shown. The true inclination is i∼16 deg, as determined by the best fit of the computed and observed polarization curves (right). The peak-to-peak variation in the normalized Stokes parameters is ∼0.08%.

the atmosphere. Due to the proximity to the star, hot giant planets with orbital period = 3 days may develop peculiar atmospheres and even extended hydrogen halos which effectively scatter the light in the blue spectral region. This can give rise to a degree of polarization detectable with DIPOL-2.

Scattering of photons by free electrons of the circumstellar plasma in massive hot binary stars yields an efficient tool for studying the binary parameters and the properties of the circumstellar matter. Figure 3.5 shows an example of a geometric model we developed to analyze the observed polarimetric behaviour of HD48099, a O5.5V+O9 V double-lined short-period (3.078 days) spectroscopic binary in the Mon OB2 association. The colliding wind outflow forms a scattering cloud between the components. The model provides a good fit to the observations with the orbital inclination value i ∼16 deg, important for constraining the masses of the components in this non-eclipsing binary.

Two near-simultaneous supernovae in Arp 299

The researchers at FINCA have used state-of-the-art adaptive optics (AO) imaging techniques on the 8-metre ESO VLT and Gemini-North telescopes, as well as high spatial resolution radio observations to investigate the supernova (SN) rates and properties within the nuclear regions of luminous infrared galaxies (LIRGs) which are locally rare but dominate the massive star formation at redshifts between ∼1 and ∼2. As a part of this project two SNe that exploded by chance within only a few days of one another in two different components of the interacting luminous infrared galaxy Arp 299 were investigated by **Erkki Kankare**, **Seppo Mattila**, **Jari Kotilainen** and their collaborators incl. Stuart Ryder (AAO), Cristina Romero-Cañizales (Pontificia Universidad Católica de Chile) and Miguel Pérez-Torres (Instituto de Astrofísica de Andalucía). So far, Arp 299 has hosted seven optically detected SNe whereas its total core-collapse SN rate has been estimated to be 1.6-1.9 SNe yr^{-1} making it one of the most prolific SN factories in the local Universe

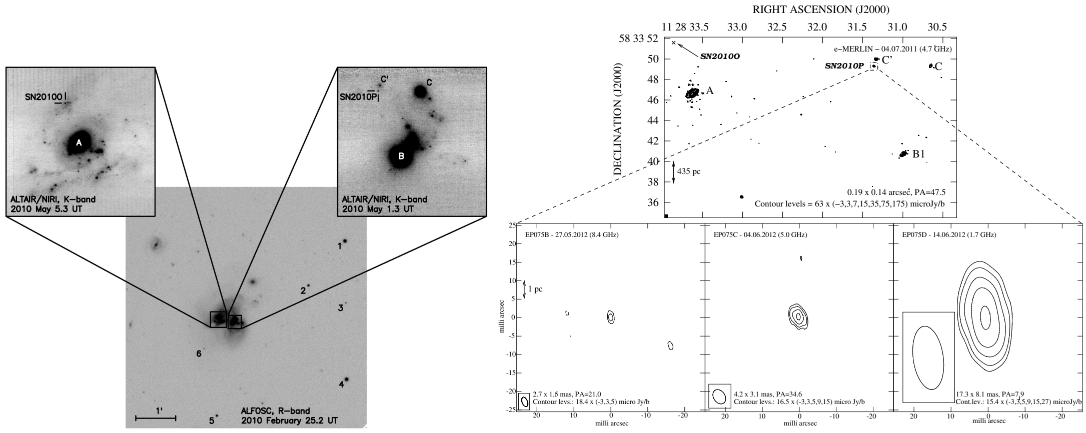

Figure 3.6: *Left*: 6 × 6 arcmin^2 R-band subsection of Nordic Optical Telescope (NOT) ALFOSC image of the Arp 299 field, and 20 × 20 arcsec^2 subsections of K-band Gemini-North ALTAIR/NIRI AO images of SN 2010O and SN 2010P. IR bright components of Arp 299 are marked in the K-band images. *Right top*: e-MERLIN contour image of Arp 299 at 4.7 GHz. The main radio sites are indicated with the letters A, B, C' and C, the position of SN 2010O is represented by a cross, and SN 2010P is enclosed by a box.*Right bottom*: The European VLBI Network (EVN) contour images of SN 2010P at 8.4, 5.0 and 1.7 GHz (from left to right). Figures from Kankare et al. (2014) and Romero-Cañizales et al. (2014).

Data were used from a number of telescopes including Gemini-North and Nordic Optical Telescope (NOT). SN 2010O that exploded in Arp 299-A (Fig. 3.6) was found to be photometrically and spectroscopically similar to many normal Type Ib SNe that originate from massive stars that have lost their hydrogen envelope prior to the explosion. Multi-wavelength observations of SN 2010P that exploded close to the C' nucleus suggested it to be a Type IIb SN with some hydrogen still left at the time of the explosion. We also used these SNe to investigate the extinction within Arp 299 and found the Galactic extinction law to describe well the host galaxy line-of-sight extinction to SN 2010O in the spiral arm of the A component. However, in the case of SN 2010P the Calzetti et al. (2000) attenuation law for starburst galaxies was found to better describe the dust properties of the IR bright C' nucleus of Arp 299 with a very high amount of extinction $A_V \sim 7$ mag.

Radio follow-up observations of SNe 2010O and 2010P were carried-out using the Multi-Element Radio Linked Interferometry Network (MERLIN), the Very Large Array (VLA) and the European very long baseline interferometry (VLBI) Network (EVN). SN 2010P was followed through its optically thin phase in epochs ranging from ∼1 to ∼3 yr after its explosion date, indicating a very slow radio evolution and a strong interaction of the SN ejecta with the circumstellar medium, making it the most distant and most slowly evolving Type IIb radio SN studied.

The red supergiant progenitor of SN 2008bk

Target of opportunity (ToO) observations using the NAOS CONICA adaptive optics (AO) system on the VLT were used in an earlier study by **Seppo Mattila** and collaborators (incl. Stephen Smartt and Justyn Maund, Queen's University Belfast) together with

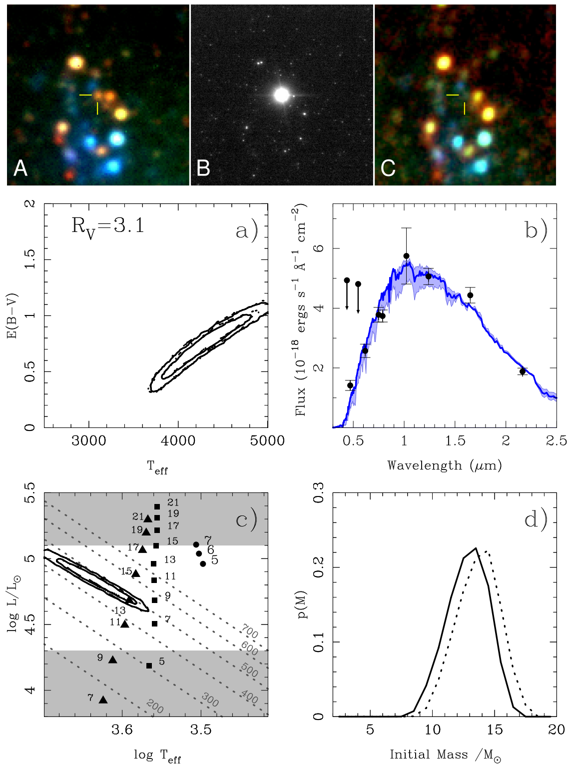

Figure 3.7: *Top*: The explosion site of SN 2008bk as seen by the ESO VLT and NTT. (A) Pre-explosion color-combined optical-near-IR VLT image showing the red supergiant star coincident with the SN position. (B) Our post-explosion Ks-band adaptive optics VLT image showing the SN near the maximum light. (C) post-explosion late time color-combined optical-near-IR NTT image observed after the SN has faded away and showing the disappearance of the RSG progenitor. *Bottom*: The observed photometry, and detection limits, of the progenitor compared to the best-fitting SED models. (c) The position of the progenitor on the HR diagram (countours) with the points from LMC metallicity stars stellar evolution models, with initial masses as labelled, corresponding to the positions of the end of He-burning (△), the termination point of the models (□). Figure from Maund et al. (2014).

archival pre-explosion VLT observations to identify the red supergiant (RSG) progenitor of the nearby Type II-P SN 2008bk (see Fig. 3.7). Their late-time observations from the VLT, Gemini-South and Hubble Space Telescope (HST) obtained after the SN had faded away have now confirmed that the previously identified RSG progenitor has disappeared. The disappearance of the pre-explosion source provides conclusive evidence for this to be a single massive star progenitor of SN 2008bk.

Our improved analysis, which carefully accounts for the systematics, resulted in a more precise and robust mass estimate for the progenitor star. The progenitor was found to be a highly reddened RSG with a luminosity corresponding to an initial mass of $12.9^{+1.6}_{-1.8} M_\odot$. The temperature of the progenitor was hotter than previously expected for RSGs (T $\sim$ 4330 K), but consistent with new temperatures derived for RSGs using spectral energy distribution fitting techniques. The extensive pre- and late-time post-explosion dataset from the VLT and Gemini-South makes the progenitor of SN 2008bk the most well understood progenitor of a Type II-P SN so far from pre-explosion observations.

Light black hole challenges supernova explosion models

Compact objects such as black holes and neutron stars are the end point of massive star evolution. Most of them are thought to have been formed in supernova explosions due to the collapse of the massive stellar core.

It is to be expected that the masses of the resultant compact remnants correlate with the masses of their progenitor stars which have a smooth distribution in the range from the heaviest to the lightest stars. Surprisingly, the observed distribution of compact object masses seems to have a gap in the range between 2 to 5 solar masses. This gap, whose existence in the current sample of the mass measurements was fairly well established, has become a significant challenge to our understanding of compact object formation.

However, the existence of the gap has been brought into question. In a paper published in the Monthly Notices of the Royal Astronomical Society, **Sergey Tsygankov** and his collaborators in the University of Oulu, University of Turku, FINCA and form Mexico and USA investigated binary system SWIFT J1753.5-0127 which exhibits X-ray properties typical for the black hole binary. For the first time, the authors performed the analysis of spectroscopic data to determine the system parameters and showed that is hosts one of the smallest stellar-mass black hole found to date, with the mass below 4 solar masses.

The presence or absence of the mass gap is a critical clue in understanding the formation of neutron stars and black holes and the engine behind supernova explosions. The result of the paper supports the possibility of existence of compact objects in the mass gap. This conclusion greatly limits the formation scenarios. For instance, in the rapid supernova explosion mechanisms, it is not possible to produce the compact objects with masses 3–5 solar masses, even accounting for the binary evolution effects. The authors suggest that the black hole in SWIFT J1753.5-0127 can either be produced in the delayed explosion or be the result of the accretion-induced collapse of a neutron star.

Active late-type stars

Thomas Hackman continued his research of active late-type stars using Doppler imaging via spectroscopy and spectropolarimetry and time-series analysis of photometry. The methods utilise the fact that large spots and magnetic field structures on the surface of a star will produce measurable variations in the brightness and photospheric spectral lines. The research was conducted in cooperation with the Academy of Finland Centre of Excellence ReSoLVE, the MHD group at the University of Helsinki and researchers at the Uppsala University.

The results of a Doppler imaging analysis of the Li-rich K-type giant DI Psc and a photometric time series analysis of s Gem where published and studies on the young DY Dra type stars AF Lep and LQ Hya where submitted for publication. Hackman also continued analysing observations with HARPSPol@ESO3.2m in cooperation with Uppsala University. These and previous studies show, that although stars are in different evolutionary states, the magnetic activity is mainly dependent on the rotation velocity and depth of the convection zone. Thus, even evolved late-type stars can be used as analogues of the young Sun. Furthermore, binary stars (e.g. s Gem) seem to show more regular patterns of activity evolution than single stars (e.g. LQ Hya).

Stellar variability studies

The research of **Pasi Hakala** has followed three different main lines. Firstly, Hakala and his collaborators have been studying X-ray binaries at the optical and NIR wavelengths. In particular, their recent research in this area, ased on NOT data, has put strong constraints on the minimum distance (and thus minimum black hole mass) of the system 4U1957+115. This system now possible contains one of the most massive stellar mass black holes in a binary system. Secondly, Hakala has been involved in carrying out a high cadence variability survey of the Kepler field using the Isaac Newton Telescope (INT) on La Palma. This survey has detected 100+ new variable sources, 16 of which have been followed up using NASA's Kepler satellite. These new sources include a

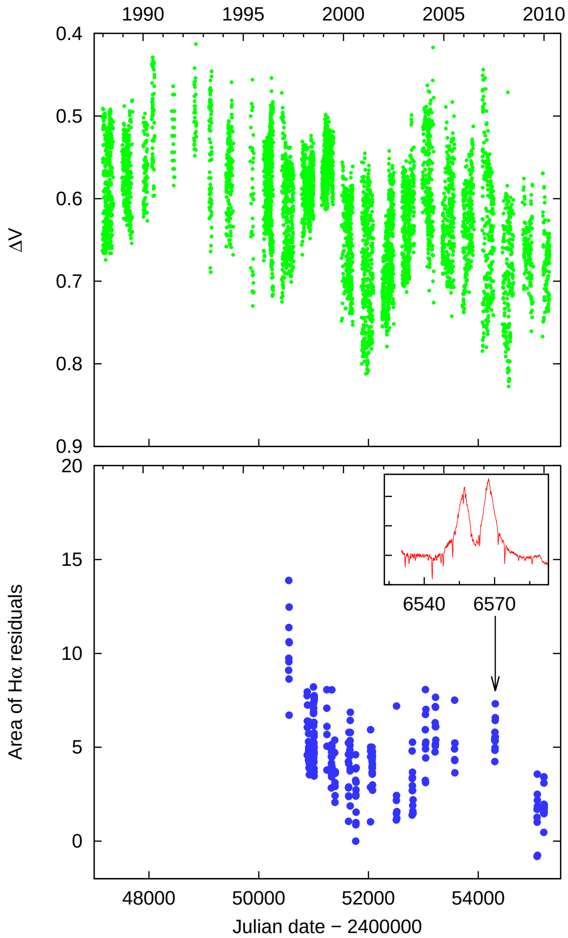

Figure 3.8: *Top*: Light curve of FK Comae in V passband. *Bottom*: excess Halpha line intensities (after subtracting the lowest activity state to remove the disc contribution). The inset shows a sample spectrum from the Halpha region from the epoch marked with the arrow.

pulsating DA white dwarf, 11 delta Sct stars which have dominant pulsation periods in the range 24 min to 2.35 h, three contact binaries, and a cataclysmic variable (V363 Lyr). One of the delta Sct stars is in a contact binary. Finally, Hakala and **Andrew Mason** have been working on a project to harvest the ESA's XMM-Newton growing data archive. They have been developing scripts to automatically re-analyse the XMM-Newton data looking for very short period systems missed by the standard analysis. The project is still under development.

Correlating magnetic activity in different layers of stellar atmosphere

FK Comae is a fast-rotating, giant star: a prototype of a group of active G–K type stars. These stars are single, rotate fast, and show signs of magnetic activity in their photosphere and chromosphere. **Heidi Korhonen** and Krisztian Vida have studied long-term photometric and spectroscopic observations of FK Com (see Fig. 3.8).

They constructed maps of the stellar surface spot configurations based on light curves (photometric inversion) and also spectra (Doppler imaging, which gives more detailed and reliable results). The Halpha region is a well-known proxy for higher layers of the stellar atmosphere, the chromosphere. This spectral region is quite spectacular in FK Com: instead of an absorption line, as is usually seen in stars, it shows large double peaked emission feature. This peculiar shape most likely indicates a disk around the star, but the exact shape of the emission is changing too. These changes are indications of hot plages and prominence loops present on FK Com. Using Halpha spectra from two consecutive nights Korhonen and Vida found small-scale fast variability during one observing night on the time scale of hours. The shape of the line profile seems to change between the nights more significantly, though. The first observing night, showing higher Halpha emission level and a more asymmetric shape, coincided with the most spotted phase, indicating that during high magnetic activity the chromosphere is also more variable on short time scales.

From higher resolution Halpha spectra Korhonen and Vida found that prominences are often present in the chromosphere: these structures reach up to 1-2 stellar radii and are stable for multiple stellar rotations. By comparing the Halpha spectra to photometric measurements, they could also correlate the magnetic activity seen in the chromosphere and the photosphere. It seems that on the rotational time scale the active regions in the photosphere (the darker, spotted phases) are often, but not always, correlated with the increased Halpha emission (active chromospheric regions). Similar behaviour is also seen on the Sun. Interestingly, this correlation does not stand on longer term: for a few years between 2000 and 2006 they seem to be correlated (the Halpha emission decreases with the star getting fainter), which could be explained by plage-dominated activity (i.e., the main reason of the long-term trends in the light curve is the change of bright region on the surface instead of spottedness), but this theory is not supported by the magnitude-colour diagrams. A possible explanation for this phenomenon could be, that the changes in chromospheric activity are following the quasi-periodic trends of the photosphere (that could be similar to the 11 year-long cycle of our Sun), but it is 1-2 years 'late'.

Early history of the Sun

Mauri Valtonen together with Aleksandr Mylläri (St.George's Univ., Grenada), Anisa Bajkova and Vadim Bobylev (Pulkovo Obs., Russia) has studied the disruption of star clusters in our galaxy, looking in particular at the history of the star cluster where the sun was born. Computer simulations of star orbits in the Galaxy were compared with stellar observations in our local neighborhood. It was concluded that within 100 pc from us we could find up to 100 stars which originated with the sun in a common star cluster 5 billion years ago. By now the stars of this cluster are not gravitationally bound together but form an arc that covers about 1/3 of solar orbit about the Galactic centre. The work will become more precise when the Gaia measurements are released.

4. Instrument development

4.1 Dipol-2

Within the DIPOL-2 project **Vilppu Piirola** and **Andrei Berdyugin** have continued developing new high-precision broad-band polarimeters, capable of measuring polarization with the precision at the 10^{-5} level, simultaneously in three passbands (BVR). The work has been carried out in collaboration with prof. Svetlana Berdyugina, Kiepenheuer-Institut Fur Sonnenphysik (KIS), Freiburg, Germany. The first copy of the instrument has been used in 2011-2014 at the remotely operated KVA-60 telescope on La Palma, Canary Islands, for studies of polarized light from exoplanet atmospheres, Interstellar dust and magnetic field in our Galaxy and circumstellar matter in strongly interacting massive binaries. A particular example is the study of interstellar polarization and the galactic magnetic field near the heliopause, within the distance of 40 pc from the Sun. Although the amount of interstellar polarization at such distances is $p < 0.005$–0.015%, DIPOL-2 can measure it with sufficient accuracy.

Two other copies of DIPOL-2 have been built at FINCA in 2014 with the support from KIS, for planned long-term projects at other remotely controlled telescopes, e.g. UH88 (2.2 m) telescope at Mauna Kea, and T60 (60 cm) at Maui, Haleakala, Hawaii. These polarimeters have been installed in April 2014 to the UH88, and in December 2014 to the T60 telescope. Four successful observing runs have already been carried out in 2014 remotely from Finland, amounting to a total of >30 nights at the UH 2.2 m telescope on Mauna Kea. With the access to remotely operated 2 m class telescopes, the simultaneous three-color (BVR) polarimeter DIPOL-2 will add significant new potential to our research.

4.2 NOT Transient Explorer

In order to get involved in future ESO instrumentation projects and to engage collaboration with groups which have already first-hand experience in building instrumentation for ESO, FINCA has from the beginning been involved in the new instrument for the Nordic Optical Telescope, NOT Transient Explorer (NTE). This instrument is being designed and built by a group at the Niels Bohr Institute, Univ. of Copenhagen. This group has previously been involved in designing and building the superb XShooter instrument for the ESO VLT. The NTE instrument (Fig. 4.1) utilizes novel design approaches which will make it and the NOT equal to none in the world of 2.5m telescopes. It has two modes: medium resolution spectroscopy from UV to near-IR, and simultaneous photometric observations both in visible and near-infrared. FINCA staff has provided several science cases (e.g. on AGN host galaxies and supernovae) for this new instrument, which have helped to shape the novel instrument concept. FINCA staff has also participated

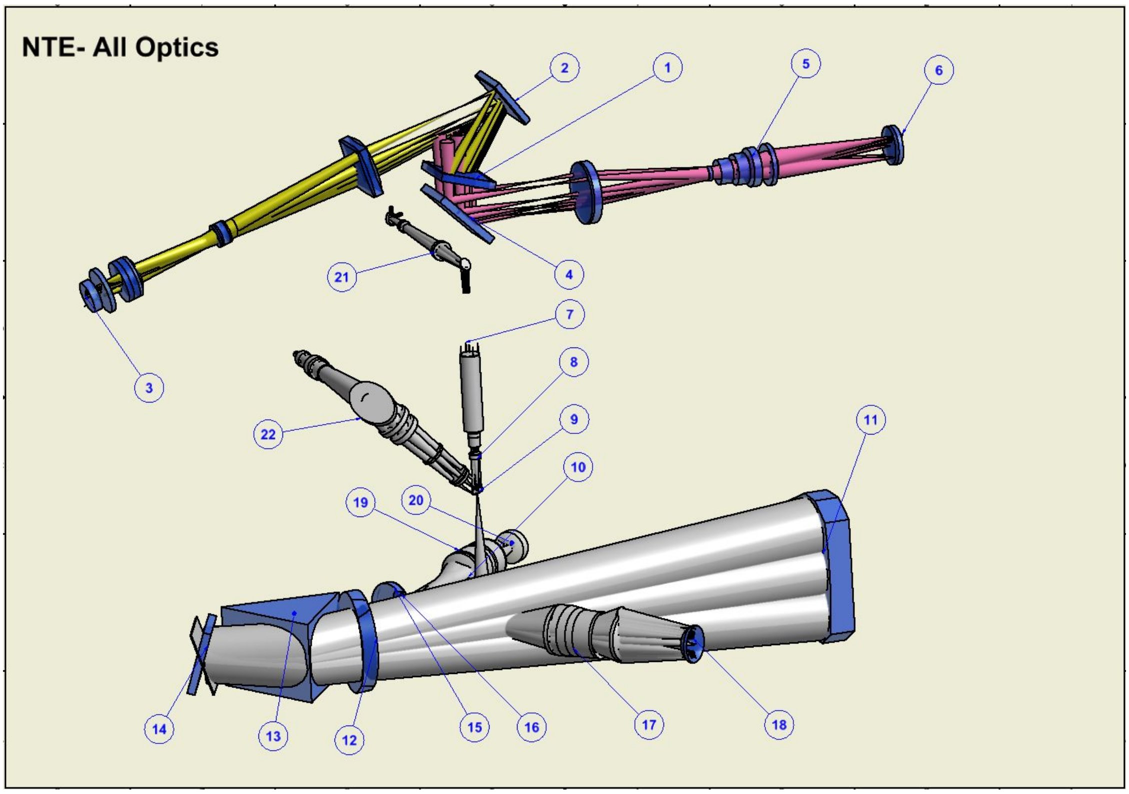

Figure 4.1: Schematic illustration of the NTE optics (M. Andersen, Niel Bohr Institute, Copenhagen).

in the Phase A study meeting (**Jari Kotilainen**) and the NTE pre-kick-off meeting in December 2013 (**Seppo Mattila** and **Heidi Korhonen**), both in Copenhagen. FINCA is committed to continue working towards the realisation of this instrument that will keep the Nordic astrophysics in the forefront of research. Participation in the NTE can also provide an important stepping stone for FINCA to become involved in instruments for the ESO telescopes.

5. Teaching

5.1 National collaboration in astronomy teaching

In 2014, FINCA staff (mainly **Seppo Mattila**, **Heidi Korhonen**, and **Kari Nilsson**) organised two courses on hands-on teaching of observational astronomy. These courses were organised as a national collaboration between the four Finnish universities that teach astronomy (Turku, Helsinki, Oulu, Aalto), and are expected to have important value in educating a competitive future user community in Finland to utilize the observing facilities of ESO.

FINCA staff started a new course in 2013 that made use of the NOT by remote observations from Tuorla Observatory. The course was very popular among the students and was integrated as a part of the astronomy teaching programmes of Universities of Turku and Helsinki, and is also offered for the students from Oulu and Aalto. Next edition of this course took place at Tuorla Observatory in University of Turku in the autumn of 2014. It was attended by a total of 20 students from all the universities in Finland with astronomy teaching (9 students from Helsinki, 7 from Turku, 3 from Oulu and 1 from Aalto). The course was organized as a one week intensive course at Tuorla Observatory followed by independent work on the obtained data. The programme included afternoon lectures given by researchers from FINCA which were followed by sessions dedicated to preparation of observations and project work. The students were divided into five groups with different science project to be carried-out using remote observations with the NOT. The projects were supervised by the staff of FINCA and University of Helsinki.

A course concentrating on more advanced data reduction and analysis methods and the use of ESO data was organised by FINCA staff in spring 2014 as a follow-up to the successful 2013 NOT observing course. This course included teaching in the form of lectures and supervised hands-on work on the data during five half a day sessions in Turku and Helsinki and independent work. The lectures covered the ESO telescopes and instruments, the use of the ESO Science Archive and ESO data reduction pipelines, as well as the commonly used methods for photometry, astrometry, automatic source extraction and characterization in astronomical images. Writing of successful observing proposals to ESO was also covered as a part of the course.

These courses have turned out to be a very efficient way in training the M.Sc and PhD students in observational astronomy. By continuing to organising these courses FINCA aims at taking a more important role in coordinating the teaching of observational optical, infrared and submillimetre astronomy in the Finnish universities.

Figure 5.1: *Top, left and bottom*: Pictures from the NOT observing course (Kari Nilsson and Jyri Näränen). *Right*: Three-colour image of the inner parts of the Tarantula Nebula. The image was constructed by Joonas Saario from B, V and R band best seeing frames obtained with FORS2 and retrieved from the ESO archive during the spring 2014 FINCA course on the use of ESO data (ESO and Joonas Saario).

5.2 Lectured courses

Basic level

S. Comerón	Introduction to Astronomy	2	Oulu, co-lecturer
K. Nilsson	Optics (Optiikka)	4	Turku
S. Tsygankov	Introduction to Astronomy	2	Oulu, co-lecturer

Intermediate level

S. Comerón	Galaxies	6	Oulu
	Introduction to Cosmology	5	Oulu
K. Nilsson	Laboratory works I (Tähtitieteen Harjoitustyöt I)	4	Turku, co-instructor

Advanced level

R. De Propris	Galactic Astronomy course	5	Turku
T. Hackman	Stellar magnetic activity	5	Helsinki
H. Korhonen	Special topics in Astronomy - Exoplanets	4	Turku
	Methods of observational astrophysics I	6	Turku, coordinator
	Methods of observational astrophysics II	5	Turku+Helsinki, co-lecturer
J. Kotilainen	Quasar Research	6	Turku
	Observational astronomy I (Havaitseva tähtitiede I)	5	Turku, co-lecturer
S. Mattila	Methods of observational astrophysics I	6	Turku+Helsinki, co-lecturer
	Methods of observational astrophysics II	5	Turku+Helsinki, coordinator
	Stellar structure and evolution	8	Turku, co-lecturer
K. Nilsson	Methods of observational astrophysics I	6	Turku+Helsinki, tel. operator
	Methods of observational astrophysics II	5	Turku+Helsinki, co-lecturer
S. Tsygankov	Observational astrophysics and data analysis	6	Oulu, co-lecturer

5.3 Completed theses

MSc theses

Jussi Harmanen, "*The evolution of supernova 2011ap form near-UV to infrared*" (Supernovan 2011ap kehitys lähiultravioletista infrapunaan), University of Turku, supervisor: Seppo Mattila.

Teppo Heikkilä, "*"Constraints for core-collapse supernova progenitors with the Chandra X-ray Observatory"*, University of Turku, supervisor: Seppo Mattila.

Emilia Järvelä, "*Multifrequency study of Narrow-line Seyfert 1 galaxies"*, Aalto University, supervisor: J. León-Tavares

Vandad Fallah Ramazani, *"Very High Energy Gamma-Rays emitting BL Lac's Population Study"*, University of Turku, supervisor: Elina Lindfors

PhD theses

J. VanderBeke, "*"Exploring galaxies through stellar kinematics and globular clusters"*, University of Ghent, Belgium, supervisor: Roberto De Propris.

6. Other research activities

Memberships in conference SOC/LOC and other committees

S. Comerón	Member of the Board of the Finnish Astronomical Society
T. Hackman	Chair for the NOT Observing Programmes Committee and the Instrument User Group on High-Resolution Optical Spectroscopy.
J. Kotilainen	Finnish delegate in ESO Council
	Finnish National Committee of IAU, member
	Finnish National Committee of COSPAR, member
	SOC, Astronomers Days 2014, Olavinlinna, 26.-28.5.2014
H. Korhonen	ESO OPC, panel member, periods 94-95, co-chair of the stellar panel D2 in both periods.
	Chair of OPTICON Time Allocation Committee
	Remote reviewer in the ERC Consolidator Grant 2014 call for proposals
	Board member of the OPTICON working group 13, "Enhancing Community Skills"
	Member of IAU working group "Impact of Magnetic Activity on Solar and Stellar Environments"
	Science Team and board member, NOT Transient Explorer (NTE)
S. Mattila	Substitute member of the Nordic Optical Telescope (NOT) OPC
	Member of the board of the Doctoral Programme in Physical and Chemical Sciences of the Univ. of Turku graduate school (UTUGS)
	Science Team and board member, NOT Transient Explorer (NTE)
	Reviewer of research infrastructure proposals, Ministry of Education, Youth and Sports, Czech Republic
	Substitute member of the board of Finnish Centre for Astronomy with ESO

Conference presentations

R. De Propris	"Searching for Feedback" (invited talk), Sesto Pusteria, July 2014
S. Comerón	“ARRAKIS: Atlas of Resonance Rings As Known In the S4G” (oral) at the Astronomer’s Days 2014, Savonlinna, 26-28 May 2014.
	“Evidence for concurrent growth of thick discs and central mass concentrations from S4G imaging” (oral) in *"The Formation and Evolution of Exponential Disks in Galaxies"* Workshop in Flagstaff, Arizona, USA, 5-9 October 2014.
H. Korhonen	"Hot topics in stellar astrophysics" (invited review) in *"OPTICON Awareness conference"*, Sofia, Bulgaria, September 25 - October 1.
	Star-planet connection" (invited review) in *"OPTICON Awareness conference"*, Sofia, Bulgaria, September 25 - October 1.
J. Kotilainen	"Dissecting the Bird: a spectacular off-nuclear LIRG starburst with gas outflows" (oral) in *"Star formation in galaxies: from small to large scales"*, EWASS 2014, Turku, 30.6.-4.7.2014.
	"Gamma-ray Narrow-Line Seyfert 1 galaxies: relativistic jets in spirals? (oral)" in *"Tuorla-Tartu annual meeting 2014: Small and Large scale Universe"*, Turku, 1.-3.10.2014.
E. Lindfors	"Cherenkov Telescope Array - A Sensitive Probe of the Extreme Universe" (invited talk), in Quantum Universe, 16.4-17.4.2014, Groningen
J. León-Tavares	in Extragalactic jets from every angle 15-19Sep, Galapagos, Ecuador
S. Mattila	"Supernovae in nuclear environments" (invited talk) in The fifth Gaia Science Alerts workshop, 9-12 Sept. 2014, Warsaw, Poland
S. Tsygankov	"Power spectra of transient X-ray pulsars: observational manifestation of the disk-magnetosphere interaction" in COSPAR meeting, 2.-10.8.2014, Moscow, Russia

Other talks

S. Comerón	“History of science talk: The Road to the Big Bang”, Department of Physics, University of Oulu (Finland), 29 October 2014
	“Two alternatives to the standard cosmological model”, Department of Physics, University of Oulu (Finland), 24 March 2014
	“Is dark matter the most valid explanation for the mass which is missing in the Universe?”, Instituto de Astrofísica de Canarias (Spain), 4 February 2014
T. Hackman	“Stellar spot activity - methods and results”, Department of Physics, University of Helsinki, September 26, 2014.
H. Korhonen	"The secrets of mercury-manganese stars, Tuorla Observatory, 7 March 2014
	"Stellar activity and exoplanets" , Stellar Astrophysics Centre, Aarhus University, September 30
E. Lindfors	"Very High Energy gamma-rays from Flat Spectrum Radio Quasars ", 4.2.2014, Brera Observatory
J. León-Tavares	"The nature of the radio core", Centro de Radioastronomia y Astrofisica UNAM, Morelia Mexico, 20 February
S. Mattila	"Glimpses to final moments of stars" 24th Jan 2014, Tuorla
	"The cosmic core-collapse supernova rate" in "Tuorla-Tartu annual meeting 2014: Small and Large scale Universe", Turku, 1.-3.10.2014.
K. Nilsson	"Ilmakehä ja maanpäälliset tähtititieteelliset havainnot" (invited talk), Tekniikan Päivät 2014, Dipoli, Espoo, 16.1.2014
	"Ilmakehä ja maanpäälliset tähtititieteelliset havainnot" (invited talk), Tekniikan Päivät 2014, Turku, 25.1.2014

Research Visits

R. De Propris	Bristol, UK, July 2014
T. Hackman	Uppsala University, Sweden, 23.-25.4. 2014, collaborators O. Kochuchov and L. Rosén
H. Korhonen	AIP, Potsdam, October 12-17, collaborators S. Hubrig and S. Järvinen
J. Kotilainen	University of Padova, 7.-8.3.2014, collaborators R. Falomo and D. Bettoni
J. León-Tavares	Centro de Radioastronomia y Astrofisica UNAM, Morelia Mexico, 15-20 February, Luis Zapata
E. Lindfors	Brera Observatory, 3.-7.2.2014, Fabrizio Tavecchio
	MPI Munich, 10.2.-11.2.2014, Daniel Mazin
S. Mattila	Queen's University of Belfast, 5-7 Feb. 2014, participating in a GAIA-PESSTO Workshop
	University of Cambridge, 21.-23.5 2014, collaborators H. Campbell, M. Fraser, S. Hodgkin, N. Walton and N. Blagorodnova
V. Piirola	ING/WHT 4.2m, La Palma, 11.-19.1.2014
	Univ. of Hawaii, Mauna Kea, 7.-20.4.2014
	ING/WHT 4.2m La Palma, 10.-21.5.2014
	Univ. of Hawaii, Haleakala, Maui, 1.-11.12.2014
S. Tsygankov	Institut für Astronomie und Astrophysik, Kepler Center for Astro and Particle Physics, Universität Tübingen, Germany, 17.-27.09.2014, collaborator: Dr. Victor Doroshenko

Hosted visitors

Ulisses Barres de Almeida Centro Brasileiro de Pesquisas Fisicas - CBPF/MCT, 31.3-3.4.2014 – Host: E. Lindfors

Malcolm Bremer University of Bristol, August 2014 – Host: R. De Propris

Bernardo Cervantes-Sodi Korean Institute for Advanced Study, Seoul, 7-11 December – Host: S. Comerón

Helen Jermak and Iain Steele Astrophysics Research Institute, Liverpool John Moores University, 1.3-3.3.2014 – Host: E. Lindfors

Erkki Kankare Queen's University of Belfast, 17-21.11.2014 – Host: S. Mattila

Rubina Kotak Queen's University of Belfast, 27.7.-1.8.2014 – Host: S. Mattila

Peter Lundqvist Stockholm University, 26.7.-3.8.2014 – Host: S. Mattila

Miguel Pérez-Torres Instituto de Astrofísica de Andalucía, 1-8.8.2014 – Host: S. Mattila

Cristina Romero-Cañizales Pontificia Universidad Católica de Chile, 9-28.2.2014 – Host: S. Mattila

Krisztián Vida Konkoly Observatory, Hungary, 6.10. - 19.12. – Host: H. Korhonen

Petri Väisänen SAAO, South Africa, 20.-31.10.2014 – Hosts: J. Kotilainen and S. Mattila

Awards and recognitions

H. Korhonen	Cool Stars 18, June 9-13, Flagstaff USA, main organiser of the three hour long splinter session "Stellar surfaces with high spatial and temporal resolution", approximately 120 participants in the splinter (more than 400 in the whole conference).
	Head of the PhD thesis committee of Pieter Gruyters, "Exploring the Chemical Evolution of Globular Clusters and their Stars", October 2014, University of Uppsala, Sweden
J. Kotilainen	Pre-examiner of PhD dissertation, Johanna Malinen, Interstellar medium and initial stages of star formation: comparing simulations and observations, University of Helsinki, February 2014

7. Publications

[1] Abergel, A., Ade, P. A. R., Aghanim, N., Alves, M. I. R., Aniano, G., Armitage-Caplan, C., Arnaud, M., Ashdown, M., Atrio-Barandela, F. et al., (including **León-Tavares**, J.), Planck Collaboration, *Planck 2013 results. XI. All-sky model of thermal dust emission*, 2014, A&A, 571, A11.

[2] Ackermann, M., Ajello, M., Allafort, A., Antolini, E., Barbiellini, G., Bastieri, D., Bellazzini, R., Bissaldi, E., Bonamente, E., Bregeon, J., et al. (including **Lindfors**, E., **Nilsson**, K., **Nieppola**, E.), MAGIC Collaboration, *Multifrequency Studies of the Peculiar Quasar 4C+21.35 During the 2010 Flaring Activity*, 2014, ApJ, 786, 157.

[3] Ade, P. A. R., Aghanim, N., Armitage-Caplan, C., Arnaud, M., Ashdown, M., Atrio-Barandela, E., Aumont, J., Baccigalupi, C., Banday, A. J., Barreiro, R., et al. (including **León-Tavares**, J.), Planck Collaboration, *Planck 2013 results. XVII. Gravitational lensing by large-scale structure*, 2014, A&A, 571, A17.

[4] Ade, P. A. R., Aghanim, N., Alves, M. I. R., Armitage-Caplan, C., Arnaud, M., Ashdown, M., Atrio-Barandela, F., Aumont, J., Baccigalupi, C., Banday, A. J., et al. (including **León-Tavares**, J.), Planck Collaboration, *Planck 2013 results. XIII. Galactic CO emission*, 2014, A&A, 571, A13.

[5] Ade, P. A. R., Arnaud, M., Ashdown, M., Aumont, J., Baccigalupi, C., Banday, A. J., Barreiro, R. B., Battaner, E., Benabed, K., Benoit-Levy, A., et al. (including **León-Tavares**, J.), Planck Collaboration, *Planck 2013 results. XXXI. Consistency of the Planck data*, 2014, A&A, 571, A31.

[6] Ade, P. A. R., Aghanim, N., Alves, M. I. R., Armitage-Caplan, C., I, Amaud, M., Ashdown, M., Atrio-Barandela, F., Aumont, J., Ausse, H., Baccigalupi, C., et al. (including **León-Tavares**, J.), Planck Collaboration, *Planck 2013 results. I. Overview of products and scientific results*, 2014, A&A, 571, A1.

[7] Ade, P. A. R., Aghanim, N., Armitage-Caplan, C., Arnaud, M., Ashdown, M., Atrio-Barandela, F., Aumont, J., Baccigalupi, C., Banday, A. J., Barreiro, R., et al. (including **León-Tavares**, J.), Planck Collaboration, *Planck 2013 results. XVIII. The gravitational lensing-infrared background correlation*, 2014, A&A, 571, A18.

[8] Ade, P. A. R., Aghanim, N., Armitage-Caplan, C., Arnaud, M., Ashdown, M., Atrio-Barandela, F., Aumont, J., Baccigalupi, C., Banday, A. J., Barreiro, B., et al. (including **León-Tavares**, J.), Planck Collaboration, *Planck 2013 results. XXI. Power spectrum and high-order statistics of the Planck all-sky Compton parameter map*, 2014, A&A, 571, A21.

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