Astronomy and Astrophysics
Research Report 2010

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1.1 High-Energy Astrophysics

1.1.1 Development of the ASTRO-H satellite

A. Bamba, F. A. Aharonian and the ASTRO-H collaboration

ASTRO-H is the next generation X-ray satellite under construction in Japan. A. Bamba and F. A. Aharonian are main members of ASTRO-H mission contributing to the hardware development and science case study. Aya Bamba has a responsibility to avoid out-gas in the satellites and designed the out-gas shield for X-ray CCDs onboard ASTRO-H. Aya Bamba is also the leader for the public outreach of ASTRO-H. Felix Aharonian has been invited to the selected Science Working Group of ASTRO-H, whose main task is discussing the main science cases of ASTRO-H and making requirement for the detector design.

1.1.2 X-ray/Gamma-ray studies of Galactic accelerators

A. Bamba, A. Hayato (GSFC), T. Sato (ISAS/JAXA), K. Someya (ISAS/JAXA), Y. Terada (Saitama U.), T. Anada (ISAS/JAXA), H. Yamaguchi (RIKEN), S. Yamauchi (Nara Womens U.), et al.

We have made X-ray studies of Galactic accelerators, such as supernova remnants, superbubbles, pulsars, and white dwarfs. The most exciting discovery is the Suzaku observational fact that pulsar wind nebulae (PWNe) keep expanding up to ~100 kyr, although the timescale of the synchrotron X-ray emission is only ~60 yr for typical magnetic fields of 100 μG. Our result suggests that the accelerated electrons up to ~80 TeV can escape from the PWNe without losing most energies.

Aya Bamba joined the Very high energy gamma-ray (VHE) telescope Cherenkov Telescope Array (CTA). We made design studies of the array, from the point of view of studying Galactic accelerators. This work was reflected to an invited talk in November.

1.1.3 Diffuse emission of the galactic disk

F. A. Aharonian, S. Casanova, Y. Fukui, S. Gabici, D. I. Jones, A. Kawamura, T. Onishi, G. Rowell, K. Torii, H. Yamamoto

The observations of galactic gamma-rays with the Fermi LAT telescope in the MeV/GeV energy band and with the HESS array of imaging atmospheric Cherenkov telescopes in the TeV energy band, together with the recently reported data on the distribution of the molecular hydrogen in the Galaxy on a sub-degree scale, provides a unique opportunity for exploration of the cosmic ray density throughout the Galaxy, both on large (kpc) and small (pc) scales. In particular, we proposed a new method to address the question how γ-ray observations – when combined with the data on the molecular hydrogen obtained by the NANTEN mm-telescope – can be used to study the large-scale spatial variations of cosmic rays in our Galaxy [14]. In the second paper [13] we modeled the propagation of cosmic rays on smaller (10 to 100 pc) scales, in particular in the vicinity of young supernova remnants. Cosmic rays escaping from supernova remnants diffuse into the interstellar medium and collide with the ambient atomic and molecular gas. This results in production of gamma-rays which contain direct information about the parent population of runaway cosmic rays. We discussed such a scenario of gamma-ray production in the surroundings of the shell-type supernova remnant RX J1713.7-3946. The spectral and spatial distributions of the emission, which depend upon the source age, the source injection history, the diffusion regime, and the distribution of the ambient gas, as mapped by the NANTEN surveys, have been studied. The results may have important implications for interpretation of the results obtained with current and future gamma-ray experiments.

1.1.4 The Galactic Centre

F. A. Aharonian, M. Chernyakova, R. Crocker, S. Casanova, D. Jones

The production of the diffuse gamma-ray emission within the central ~ 300 pc region of the Galaxy has been studied in a series of papers [88, 91, 90].

In the paper by Chernyakova et al. [88], we described and sought to explain the very high energy gamma-ray emission from the central few parsecs of our Galaxy as detected by the Fermi and HESS instruments (see fig. 1). This study investigated the morphological, spectral and temporal characteristics of this central source coincident with the Galaxy's ($\sim 4 \times 10^6$ solar mass) super-massive black hole (SMBH). The detailed numerical calculations demonstrated that the inflected γ-ray spectrum of this source can be explained within a model where cosmic ray ions, injected by processes associated with the SMBH, undergo a transition from diffusive propagation of cosmic ray protons and nuclei at low energy to rectilinear propagation at high energy.

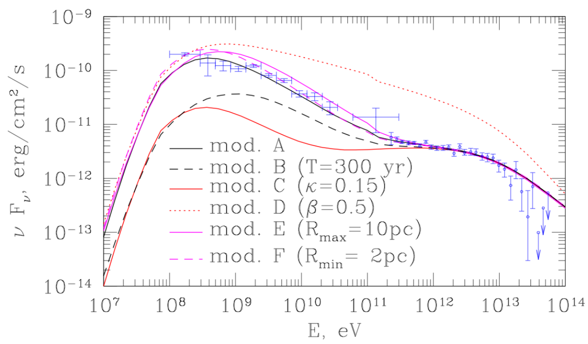

Figure 1: Observed spectrum and models for the Galactic centre's central, point-like γ-ray source [88]. The different curves correspond to different choices of the parameters describing the diffusion of cosmic rays in the GC.

These results show the acceleration of cosmic rays by the central SMBH in principle should be able to to sustain the flux of cosmic rays in the several hundred parsec region of GC. Other candidates for significant contribution are the GC region's supernovae. Even so, the TeV gamma-ray data show that even very high energy cosmic rays ($E > 10$ TeV) do not have time to penetrate into the dense cores of the region's giant molecular gas; this can be attributed to the fact that a rather fast (400-1200 km/s) wind removes them quickly from the region. This result finds observational confirmation in the radio observations with the Australia Telescope Compact Array of the Sgr B cloud. The escape of cosmic rays produced in the galactic center region and their accumulation outside the Galaxy over the time comparable to the age of the Galaxy can explain [90] the enormous features in the gamma-ray sky observed by the Fermi-LAT instrument: bilateral 'bubbles' of emission centered on the core of the Galaxy and extending to around 10 kpc above and below the Galactic plane. These structures are coincident with a non-thermal microwave 'haze' found in WMAP data and an extended region of X-ray emission detected by ROSAT. The bubbles' gamma-ray emission is characterised by a hard and relatively uniform spectrum, relatively uniform intensity, and an overall luminosity 4 x 10^37 erg/s, an one order of magnitude larger than their microwave luminosity while more than order of magnitude less than their X-ray luminosity. In ref. [90] we demonstrate that the bubbles are naturally explained as due to a population of relic cosmic ray protons and heavier ions injected by processes associated with extremely long timescale (10 Gyr) and high areal density star-formation in the Galactic center.

1.1.5 Very High Energy gamma-rays and neutrinos from RX J1713.7-3946

F. A. Aharonian, V. Zirakashvili, F. Visanni

A new numerical code, designed for the detailed numerical treatment of nonlinear diffusive shock acceleration, has been used for the modeling of particle acceleration and radiation in young supernova remnants [59]. The model is based on spherically symmetric hydrodynamic equations complemented with transport equations for relativistic particles. For the first time, the acceleration of electrons and protons by both forward and reverse shocks is studied through detailed numerical calculations. The energy spectra and spatial distributions of nonthermal emission of the young SNR RX J1713.7-3946 have been modeled and the the spectral and morphological properties of this object obtained in broad energy band from radio to very high-energy gamma rays have been calculated. The advantages and shortcomings of the so-called hadronic and leptonic models, which assume that the observed TeV gamma-ray emission is produced by accelerated protons and electrons, have been critically discussed. A new "composite" scenario has been proposed when the gamma-ray flux from the main parts of the shell has inverse Compton origin, but with a non-negligible contribution of hadronic origin from dense clouds interacting with the shell. The neutrino fluxes expected in different hadronic models have been calculated in the context of the potential of the several km-cube neutrino detector in the Mediterranean Sea.

1.1.6 Gamma-ray Flares from Star/Jet Interactions in M 87

F. A. Aharonian, M. Barkov, V. Bosch-Ramon

Non-blazar active galactic nuclei have been recently established as a class of gamma-ray sources. M87, a nearby representative of this class, shows fast TeV variability on timescales of a few days. A scenario has been proposed [10] to explain the flare gamma-ray emission in this object based on a red giant (RG) interacting with the jet at the base. We solved the hydrodynamical equations that describe the evolution of the envelope of an RG blown by the impact of the jet. If the RG is at least slightly tidally disrupted by the supermassive black hole, enough stellar material will be blown by the jet, expanding quickly until a significant part of the jet is shocked. This process can render suitable conditions for energy dissipation and proton acceleration, which could explain the detected day-scale TeV flares from M87 via proton-proton collisions. Since the radiation produced would be unbeamed, such an event should be mostly detected from non-blazar AGNs. They may be frequent phenomena, detectable in the GeV-TeV range even up to distances of 1 Gpc for the most powerful jets. The counterparts at lower energies are expected to be not too bright. M87, and nearby non-blazar AGNs in general, can be fast variable sources of gamma-rays through RG/jet interactions.

1.1.7 Limitations on the photo-disintegration process as a source of VHE photons

F. A. Aharonian, A. Taylor

We studied whether photo-disintegration is ever able to provide an effective mechanism for the production of VHE gamma-ray emission from astrophysical sources. We find that the efficiency of this process is always smaller by a factor A/Z^2 than that of nuclei cooling through Bethe-Heitler pair-production. Furthermore, for sources optically thin to TeV emission, we find that the efficiency of this process can be no more than $3 \times 10^{-5}(R_{\rm source}/R_{\rm Larmor})$, where $R_{\rm source}$ is the source size and $R_{\rm Larmor}$ is the CR nuclei Larmor radius. We conclude that, this process is not able, in contrast to the recent optimistic claims, to provide an effective mechanism for VHE gamma-ray emission from astrophysical sources [3].

1.1.8 Point like non-variable extragalactic gamma-ray sources associated with accelerators of highest energy cosmic rays

F. A. Aharonian, S. Kelner, Y. Prosekin

Ultra-high energy cosmic-rays cannot reliably point back to their acceleration sites due to their deflection by the intergalactic magnetic field (IGMF). Moreover, a “direct” localisation is limited by the interactions of CRs with the cosmic microwave background (CMB) radiation within a radius of ~ 100 Mpc. However, after the passage of ~ 10 Mpc, protons only slightly deviate from initial direction provided that IGMF does not exceed 10^{-8} G. Remarkably, 10 Mpc propagation length appears sufficient to produce a considerable amount of secondary ultra-relativistic particles whose propagation is in the same direction as the parent particle. In interactions with CMB, protons lose their energy mainly via photo-meson processes leads to the production of gamma-rays, electrons, positrons, and neutrinos. If $B \geq 10^{-10}$ G, these secondary electrons are cooled predominantly via synchrotron emission if . Since the cooling times of electrons are very short, the electrons lose the bulk of their energy before any significant deviation. This results in a small apparent angular size of gamma-ray sources.

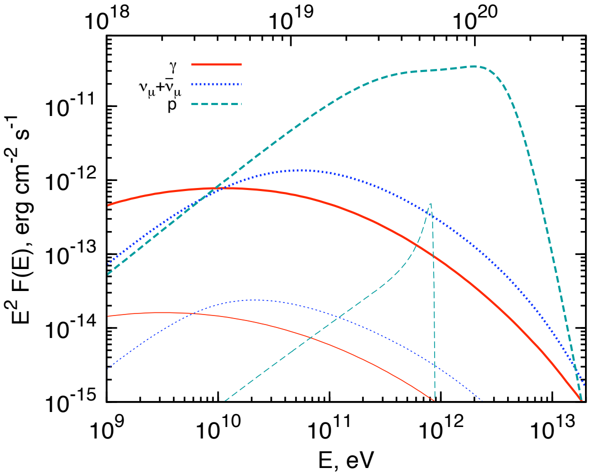

Figure 2: Spectra of gamma-rays, muon neutrinos and protons observed within a polar angle of 3° from two identical sources located at $r = 30$ Mpc (thick lines) and $r = 300$ Mpc (thin lines). The upper energy scale is for protons and neutrinos, the lower energy scale is for gamma-rays. The calculations are performed for the proton spectrum $E^{-2}\exp(-E/(3\cdot 10^{20}\text{eV}))$, and a total power of injection 10^{44} erg/s with a IGMF strength of 1 nG.

Characterising proton propagation from sources depends on the strength and large-scale structure of the IGMF. A feasible solution of this problem is to model the IGMF as a purely turbulent magnetic field which has a coherence length of 1 Mpc. Deflections of protons can then be treated as small-angle scattering on the irregularities of the IGMF. By solving the Boltzmann transport equation in the limit of the small-angle and continuous energy-loss approximations, we have calculated [5] the energy and angular distribution of protons for spherically symmetric sources with power-law injection spectra and an exponential cutoff .

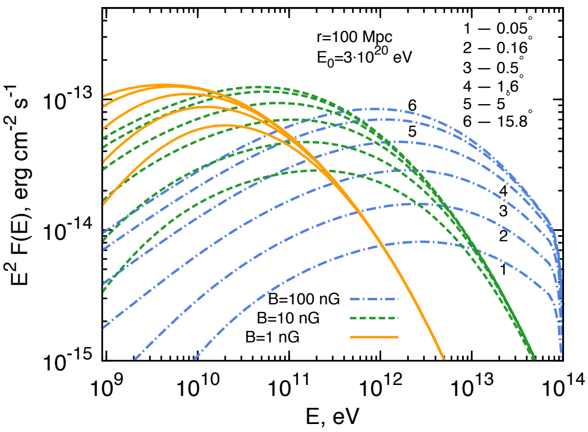

Figure 3: Spectra of gamma-rays observed within different polar angles from a source located at a distance $r = 100$ Mpc. The calculations are performed for three different IGMF strenths; $B = 1, 10$ and 100 nG.

Figure 2 shows the results of detailed numerical calculations. It illustrates that the proton fluxes within small observation angles are considerably suppressed due to deflections (at low energies) and p-γ interactions (at high energies). The angular distribution of gamma-rays appears narrow and at very high energies the source becomes point-like as it is demonstrated in Figure 3.

1.1.9 High-energy emission from outflow sources

V. Bosch-Ramon

Galactic and extragalactic sources presenting relativistic outflows are powerful non-thermal emitters of radiation from radio to gamma-rays. This emission can be produced in the base of a jet, through interactions of the plasma within the jet itself or with the external medium, or at the termination region. In the case of galactic gamma-ray binaries, one can explain the observed correlations between different wavelengths adopting non only radiative but also non-radiative losses, which are expected to occur in the complex environment of these sources. The termination region of galactic high-mass microquasar jets have properties that strongly depend on the environment, which to its turn depends on the age of the jet source. Jets could be either completely disrupted or generate a hot-spot/radio lobe structure like in the FRI/FRII dichotomy of extragalactic AGN. In the case of the latter, FRI jets interacting with the medium could be emitters of non-thermal radiation detectable in the whole spectral range. At small scales, AGN jets could be powerful gamma-ray and lower energy emitters due to interactions with inhomogeneities present in the jet base, like stars and clouds.

1.1.10 A compact pulsar wind nebula model of the γ-ray-loud binary LSI +61° 303

A. Zdziarski, A.Neronov, M.Chernyakova

We study a model of LSI +61° 303 in which its radio to TeV emission is due to interaction of a relativistic wind from a young pulsar with the wind from its companion Be star. The detailed structure of the stellar wind plays a critical role in explaining the properties of the system. We assume the fast polar wind is clumpy, which is typical for radiatively driven winds. The clumpiness and some plasma instabilities cause the two winds to mix. The relativistic electrons from the pulsar wind are retained in the moving clumps by inhomogeneities of the magnetic field, which explains the X-ray variability observed on time-scales much shorter than the orbital period. We calculate detailed inhomogeneous spectral models reproducing the average broad-band spectrum from radio to TeV. Given the uncertainties on the magnetic field within the wind and the form of the distribution of relativistic electrons, the X-ray spectrum could be dominated by either Compton or synchrotron emission. The recent Fermi observations constrain the high-energy cut-off in the electron distribution to be at the Lorentz factor of 2×10^4 or 10^8 in the former and latter model, respectively. We provide formulae comparing the losses of the relativistic electrons due to Compton, synchrotron and Coulomb processes versus the distance from the Be star. We calculate the optical depth of the wind to free-free absorption, showing that it will suppress most of the radio emission within the orbit, including the pulsed signal of the rotating neutron star. We point out the importance of Compton and Coulomb heating of the stellar wind within and around the ?-ray emitting region. Then, we find the most likely mechanism explaining the orbital modulation at TeV energies is anisotropy of emission, with relativistic electrons accelerated along the surface of equal ram pressure of the two winds. Pair absorption of the TeV emission suppresses one of the two maxima expected in an orbit.

1.1.11 The High-energy, Arcminute-scale Galactic Center Gamma-ray Source

M. Chernyakova, D. Malyshev, F. A. Aharonian

Employing data collected during the first 25 months of observations by the Fermi-LAT, we describe and subsequently seek to model the very high energy (>300 MeV) emission from the central few parsecs of our Galaxy. We analyze the morphological, spectral, and temporal characteristics of the central source, 1FGL J1745.6-2900. The data show a clear, statistically significant signal at energies above 10 GeV, where the Fermi-LAT has angular resolution comparable to that of HESS at TeV energies. This makes a meaningful joint analysis of the data possible. Our analysis of the Fermi data (alone) does not uncover any statistically significant variability of 1FGL J1745.6-2900 at GeV energies on the month timescale. Using the combination of Fermi data on 1FGL J1745.6-2900 and HESS data on the coincident, TeV source HESS J1745-290, we show that the spectrum of the central gamma-ray source is inflected with a relatively steep spectral region matching between the flatter spectrum found at both low and high energies. We model the gamma-ray production in the inner 10 pc of the Galaxy and examine cosmic ray (CR) proton propagation scenarios that reproduce the observed spectrum of the central source. We show that a model that instantiates a transition from diffusive propagation of the CR protons at low energy to almost rectilinear propagation at high energies can explain well the spectral phenomenology. We find considerable degeneracy between different parameter choices which will only be broken with the addition of morphological information that gamma-ray telescopes cannot deliver given current angular resolution limits. We argue that a future analysis performed in combination with higher-resolution radio continuum data holds out the promise of breaking this degeneracy.

1.1.12 Search for transient sources and new gamma-ray loud systems in the GeV sky

M.Chernyakova, D. Malyshev

gamma-ray-loud binary systems (GRLB) are a newly identiÞed class of X-ray binaries in which either accretion onto the compact object (a neutron star, or a black hole), or interaction of an outflow from the compact object with the wind and radiation emitted by the massive companion star leads to the production of very-high energy (VHE) gamma-ray emission. Four such systems PSR B1259-63, LS 5039, LSI +61° 303 and HESS J0632+057, have been firmly detected as persistent or regularly variable TeV gamma-ray emitters. Most of the variable and transient Galactic sources of GeV gamma-ray are expected to belong to the GRLB class.

In order to find new GRLBs we analysed all the data collected by Fermi satellite and build several variability maps of the Galactic Plane on weekly and monthly timescales. Analysis of the obtained results revealed several interesting transient sources of unknown nature. Now we are looking in more details into each particular case. The work is ongoing.

1.1.13 Gamma Ray Bursts: REM Telescope observations and afterglow lightcurves

E. J. A. Meurs, L. Norci and P. Ward (DCU), S. Covino et al. (Brera Observatory)

Observations obtained with the automatic REM Telescope and other telescopes of the Gamma Ray Burst GRB060908, from less than one minute after the high-energy event up to a year later, were used to show that existing interpretative scenarios encounter difficulties in modelling all of this dataset. Well-observed cases like GRB060908 will be necessary for advancing theories of Gamma Ray Bursts.

1.1.14 High resolution echelle spectroscopy of GRB afterglows

E. J. A. Meurs, L. Norci and P. Ward (DCU), F. Fiore, V. D'Elia et al. (Rome Observatory)

High-resolution echelle spectroscopy is a relatively new and exciting tool for GRB astronomy. Data may now be obtained only minutes after a burst has occurred, which is important because of the transient nature and decreasing brightness of the afterglows. The echelle spectroscopy highlights the presence of intervening material along the line of sight, in the immediate surroundings of a burst as well as in separate intervening systems.

The high-resolution, high signal-to-noise spectrum of the 'naked-eye' burst GRB080319B was analyzed for intervening absorbers lying along the line-of-sight to this burst. The lack of variability of the column density of certain absorbing species in the distinct components of four such absorbing systems leads to rejecting the hypothesis that observed differences between GRB and quasi-stellar object MgII absorbers would be due to the different size of the respective emitting regions.

1.1.15 Echelle spectroscopy of normal OB stars

E. J. A. Meurs, L. Norci (DCU), V. F. Polcaro (Rome), R. Gualandi (Loiano)

Further spectroscopic observations of OB stars were secured at Loiano Observatory (Italy) with the 1.52 m telescope. The programme that is carried out aims at completing a census of all Northern OB stars with magnitude V<9, to find hitherto unrecognized runaway stars.

1.1.16 High-energy emission from young stellar clusters

E. J. A. Meurs, P. J. Kavanagh and L. Norci (DCU)

The youngest Galactic stellar clusters are examined at X-rays, primarily with data from the Chandra satellite, in order to investigate existing ideas about the sources of high-energy emission from these very young clusters, without having the complications of evolved binaries (i.e., X-ray binaries) or supernova remnants. The clusters were selected with ages less than 5 million years and with well-exposed Chandra observations available. This led to a sample of 13 clusters being studied for their point sources (stellar objects) as well as any diffuse emission component due to the combined effect of stellar winds.

A detailed interpretation was pursued for the cluster Westerlund 1 (Wd1), probably the most massive young stellar cluster in our Galaxy. By exception, X-ray observations with the XMM-Newton satellite were utilized for this cluster. Having established that the diffuse hard X-ray emission in Wd1 is thermal in origin (based on a spectral analysis that led to the discovery of Fe 6.7keV line emission), several potential sources for this diffuse component were examined. The origin of the diffuse hard X-ray component is most likely stellar winds, with conceivably a contribution from Pre-Main Sequence stars, while a contribution by supernova remnants is to be discarded.

A notable feature of Wd1 is that only one case of an end product of stellar evolution (that is, a stellar remnant) is known, which is a so-called magnetar (a neutron star with an extraordinarily strong magnetic field). A nearby normal stellar member of Wd1 presents itself as a possible former binary companion to the magnetar, because of its high proper motion: this could be acquired when a binary is disrupted after the supernova explosion of one member of the binary Ð the magnetar progenitor in this case. Based on this scenario, a magnetar progenitor mass not much higher than the assumed upper stellar mass for neutron star production can be deduced, thus diminishing recent claims in the literature for substantially higher progenitor masses for the Wd1 magnetar.

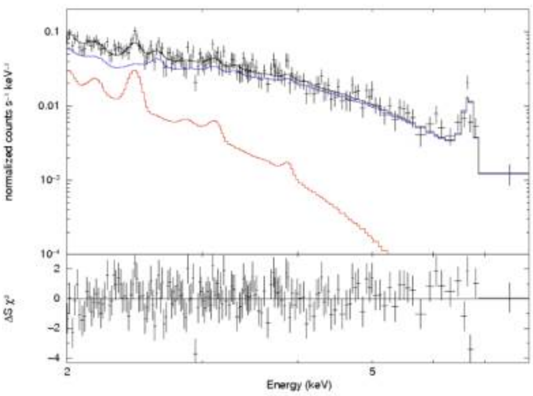

Figure 4: X-ray spectrum of the massive, young star cluster Westerlund 1, with Fe 6.7keV line emission. The XMM-Newton spectrum (points with error bars) has been fitted with a two temperature thermal model (black line). The low and high temperature components are indicated with red and blue lines, respectively. The lower panel shows the differences between the observed data points and the two temperature model fit.

1.1.17 Distribution and population size of Black Hole Binaries in the Galaxy

E. J. A. Meurs, G. O'Halloran, L. Norci and P. J. Kavanagh (DCU)

A map has been constructed showing the location of currently confirmed Black Hole Binaries in our Galaxy, based on a comprehensive review of their distances to the Sun. The observed Galactic Black Hole Binary distribution is used to obtain a population size of 1800 objects, assuming a distribution like Population II objects in view of the generally low mass stellar companions. When recurrence times and unconfirmed, candidate Black Hole Binaries are taken into account, the total number may increase to 10000 objects.

1.1.18 The distribution of core-collapse supernovae in spiral galaxies

E. J. A. Meurs, M. Molloy, L. Norci and P. J. Kavanagh (DCU)

Core-collapse supernovae are exploding massive stars and are therefore expected to occur in the disks of spiral galaxies. Yet several such supernovae have been observed away from the disks of their host galaxies. An analysis has been carried out of observational data on supernovae in edge-on spiral galaxies, in order to quantify the occurrence of core-collapse supernovae outside the disks of their host galaxies. A possible explanation for such displaced supernovae is that they acquired substantial space velocities after a companion star in a binary system exploded as supernova and an interpretative model is developed that can account for the observed galactic height distribution of the supernovae in edge-on galaxies.

1.2 Star Formation

1.2.1 Anomalous Microwave Emission

A. Scaife

The complete characterization of the "anomalous" microwave emission from spinning dust grains is a key question in both astrophysics and cosmology. It probes a region of the electromagnetic spectrum where a number of different astrophysical disciplines overlap. It is important for CMB observations in order to correctly characterise the contaminating foreground emission; for star and planetary formation it is important because it potentially probes a regime of grain sizes that is not otherwise easily observable.

Although recent results from the Planck satellite have significantly strengthened the case for its existence, the characteristics both environmental and intrinsic that affect the emission from spinning dust are still largely unconstrained.

AS is working on the identification and characterization of the anomalous emission attributed to spinning dust. As such she has been involved in a number of observational projects. Notable amongst these is the radio follow-up programme for the Spitzer and Herchel Nearby Galaxies samples (SINGS/KINGFISH), which is currently being undertaken using the GBT, AMI and ATCA telescopes in both the Northern and Southern hemispheres. This project has the joint aim of constraining the contamination of radio star formation tracers by anomalous microwave emission and using the derived corrections to employ free–free emission as a 'gold standard' for mid-infrared derived star-formation rates.

AS is PI of an observing programme with the ATCA telescope which represents the first direct use of anomalous microwave emission. This project is using the emission from the spinning dust grains to constrain the contribution of a very small grain population to the dust chemistry of circumstellar disks. This project has implications for both disk and planetary formation.

AS is the working group leader for the spinning dust working group of the MeerKAT telescope Galactic survey (MeerGAL), which was accepted in 2010 as one of the key survey projects for the new MeerKAT telescope.

1.2.2 Radio follow-up of low-luminosity protostars

A. Scaife

AS is leading an extensive programme of radio follow-up to the Spitzer cores to disks project. This project is looking at the radio luminosity of embedded protostars in the low- and very-low luminosity limit. These objects are of particular interest as they all violate the theoretical lower luminosity limit for star formation via steady accretion. Notable results from this ongoing work are the derived correlations between radio luminosity and the IR characteristics of the sources, as well as observational differences in the detection rates of protostars of differing evolutionary class. AS is also PI of a proposed extension to this programme with the ATCA telescope in the Southern hemisphere.

1.2.3 YSO NIR spectral survey: L1641 star forming region

A. Caratti o Garatti, R. Garcia Lopez, S. Antoniucci (INAF-OAR), T. Giannini (INAF-OAR), J. Eislöffel (TLS), B. Nisini (INAF-OAR), T. Ray

Low mass Young Stellar Objects (YSOs) are usually classified by the shape of their Spectral Energy Distribution (SED) into an empirical evolutionary sequence, which forms the basis of our understanding of the YSO formation process. In recent years, this classification has be shown to be limited in providing precise information on the YSO real evolutionary state. For instance geometrical effects have led to misclassifications between Class I and II objects. We carried on an in-depth study of a flux-limited sample of 27 Class I and II YSOs in L1641, based on low-resolution spectroscopy and photometry, ranging from optical to mid-IR wavelengths. The aim of this survey is to investigate the nature of these sources, deriving the main physical parameters from their spectra. Although Class I objects in our sample do not have bolometric luminosities dominated by accretion, we find that, on average, they are typically younger than CTTs. Similarly, we infer that the youngest objects have the highest accretion rates.

1.2.4 The outburst of an embedded low-mass YSO in L1641

A. Caratti o Garatti, R. Garcia Lopez, A. Scholz, T. Giannini (INAF-OAR), J. Eislöffel (TLS), B. Nisini (INAF-OAR), F. Massi (INAF-OAA), S. Antoniucci (INAF-OAR), T. Ray

Strong outbursts in very young and embedded protostars are rare and not yet fully understood. They are believed to originate from an increase in the mass accretion rate ($\dot{M}_{acc}$) onto the source. We report the discovery of a strong outburst in a low-mass embedded young stellar object (YSO), namely $2MASS-J05424848-0816347$ or $[CTF93]216-2$, as well as its photometric and spectroscopic follow-up. Using near-to mid-IR photometry and NIR low-resolution spectroscopy, we monitor the outburst, deriving its magnitude, duration, as well as the enhanced accretion luminosity and mass accretion rate. $[CTF93]216-2$ increased in brightness by ~4.6, 4.0, 3.8, and 1.9 mag in the J, H, K_s bands and at 24 μm, respectively, corresponding to an L_{bol} increase of ~20 $L_\odot$. Its early spectrum, probably taken soon after the outburst, displays a steep almost featureless continuum, with strong CO band heads and H_2O broad-band absorption features, and Brγ line in emission. A later spectrum reveals more absorption features, allowing us to estimate $T_{\rm eff}$~3200 K, M_*~0.25 $M_\odot$, and $\dot{M}_{acc}$~1.2×10^{-6} $M_\odot$ yr^{-1}. This makes it one of the lowest mass YSOs with a strong outburst so far discovered.

1.2.5 The Spitzer Survey of Interstellar Clouds in the Gould Belt. III. A Multi-Wavelength View of Corona Australis

D. E Petersson (CfA), A. Caratti o Garatti, T. Ray and the Spitzer Gould Belt Team

We present Spitzer Space Telescope IRAC and MIPS observations of a 0.85 deg^2 field including the Corona Australis (CrA) star-forming region. At a distance of 130 pc, CrA is one of the closest regions known to be actively forming stars, particularly within its embedded association, the Coronet. Using the Spitzer data, we identify 51 young stellar objects (YSOs) in CrA which include sources in the well-studied Coronet cluster as well as distributed throughout the molecular cloud. Twelve of the YSOs observed are new candidates, one of which is located in the Coronet. Known YSOs retrieved from the literature are also added to the list, and a total of 116 candidate YSOs in CrA are compiled. Based on these YSO candidates, the star formation rate is computed to be 12 $M_\odot$Myr^{-1}, similar to that of the Lupus clouds. A clustering analysis was also performed, with the finding that the main cluster core, consisting of 68 members, is elongated (having an aspect ratio of 2.36), with a circular radius of 0.59 pc and mean surface density of 150 pc^{-2}. In addition, we analyze outflows and jets in CrA by means of new CO and H_2 data. We present 1.3 mm interferometric continuum observations made with the Submillimeter Array (SMA) covering RCrA, IRS 5, IRS 7, and $IRAS18595-3712$ (IRAS 32). We also present multi-epoch H_2 maps and detect jets and outflows, study their proper motions, and identify exciting sources. The Spitzer and ISAAC/VLT observations of IRAS 32 show a bipolar precessing jet, which drives a CO (2-1) outflow detected in the SMA observations. There is also clear evidence for a parsec-scale precessing outflow, E-W oriented, and originating in the SMA2 region, likely driven by SMA2 or IRS 7A.

1.2.6 NIR spectroscopic survey of jets from massive YSOs

A. Caratti o Garatti in collaboration with B. Stecklum (Tautenburg), C. Davis (JAC), H. Linz (MPIA), T. Stanke (ESO), H. Zinnecker (AIP).

The detection and study of jets and outflows from high-mass young stellar objects (HMYSOs) is of primary importance to understand the mechanism which produces massive stars. We undertook an unbiased spectroscopic follow-up of the H_2 emission detected during our previous imaging runs (ESO-NTT/SofI, TNG/NICS), to clarify the nature and the origin of such emissions (shock vs fluorescence; jet vs photo-dissociation region), derive their excitation conditions (T, A_V), and the flow properties (mass, mass ejection rate, H_2 luminosity), correlating them with the evolutionary stage of the driving YSO.

1.2.7 Project on YSO variability

A. Caratti o Garatti, R. Garcia Lopez, A. Scholz, T. Ray, K. Covey (Uni. Cornell), J. Stauffer (SSC-CALTECH), M. Morales-Calderon (SSC-CALTECH), L. Rebull (CALTECH), R. Gutermuth (Five Col.)

We have begun a new project aimed to prove the episodic nature of the accretion mechanism in early stage YSOs, pinpointing those events produced by burst magnetospheric-accretion, and deriving an average burst frequency. This has been achieved through REM NIR time-series photometry of the sample, which have been then compared to previous archival photometric data.

We also asked for ground-based optical/NIR time-series observations with the (Rapid Eye Mount) REM telescope on La Silla, to support the Spitzer Space Telescope variability monitoring campaign of the Serpens Star Forming Region in May-June 2011. We will combine REM and Spitzer observations to investigate both short (<1 day) and long-term (up to 6 years) flux variability of the young stellar objects (YSOs) in this region, to discern the different mechanisms originating the YSO variability. In particular, REM photometry will monitor the stellar variability, whereas Spitzer data will trace changes in the circumstellar disk and envelope. Our data will be matched with proper radiative transfer models, that predict light-curve amplitude and phase as a function of wavelength. Since we cannot spatially resolve the stellar-disk system in our targets, studying variability at different wavelengths can probe their 3-dimensional geometry and structure, as well as the physical processes that are taking place.

1.2.8 X-Shooter Survey of Accretion and Ejection Properties in Very Low Mass Stars and Brown Dwarfs

A. Natta (DIAS/INAF-OAA), A. Scholz, T. Ray, E. Rigliaco (INAF-OAA)

Accretion and ejection of matter play a fundamental role in shaping the structure and evolution of circumstellar disks and, therefore, the formation and properties of planetary systems. In 2010, we have started a large project aimed at studying accretion and ejection properties in a relatively large sample of very low mass young stars and brown dwarfs using the new spectrometer at ESO/VLT X-shooter, which provides simultaneous coverage of the whole wavelength range from 300 to 2500 nm with a spectral resolution of 5000-10000. The first results for an actively accreting brown dwarf in the σ Ori star forming region have shown the potential of this instrument, which allows us to measure simultaneously a large number of accretion and massloss indicators, avoiding the problem of time variability. We are now analyzing the spectra of about 15 objects in the same region.

1.2.9 The Properties of the Lowest Mass Young Stars, Brown Dwarfs and Planemos

A. Scholz, P. Dawson, T. Ray

Our understanding of star and planet formation is guided by observations of stars in the process of formation. One fundamental part of such projects is to survey star forming regions and to compile a complete census of young stars down to the lowest masses and the earliest ages. With the help of sensitive infrared instruments, it becomes feasible to achieve this goal.

Schrödinger Fellow Aleks Scholz is leading a long-term program to identify and characterise young stellar objects and their environment. The main focus of this program is the very low mass regime, the so-called brown dwarfs and planemos with 10-100 Jupiter masses, to answer the following questions:

1) What is the lowestmass an object can have to be formed like the Sun?

2) Can these objects still harbour planetary systems?

In 2010, A. Scholz has continued to build an international collaboration to work on these problems, including team members in Toronto (Canada), Arcetri (Italy), Garching (Germany), St. Andrews (UK), Tokyo (Japan), and Zurich (Switzerland). He was able to secure a Research Frontiers grant from Science Foundation Ireland, primarily to foster these collaborations and to fund a new PhD student Paul Dawson, who has started his work on a brown dwarf survey of several star forming regions based on data from the UKIDSS project. Over the last year, the team has applied successfully for highly competitive observing time at large ground-based and space telescopes (e.g., ESO/VLT, Subaru, Gemini, and Herschel).

1.2.10 A Near-Infrared Variability Study of the Star Forming Cloud IC1396W

A. Scholz, D. Froebrich (U. Kent), C. J. Davis (JAC, Hawaii), and H. Meusinger (TLS, Tautenburg)

In collaboration with colleagues at the University of Kent (UK), the Joint Astronomy Centre (USA), and the Observatory Tautenburg (Germany), A. Scholz has finished a census of the star formation activity in the compact region IC1396W in Cepheus. The team developed a new method to identify young stars based on a combination of variability and colours. IC1396W was found to have a very low star formation efficiency of 1%, which points to an early evolutionary state (Scholz, Froebrich, Davis, Meusinger, MNRAS, 2010, 406, 505).

1.2.11 Studies of Benchmark Objects

A. Scholz and Others

The brown dwarf FU Tau is an object with properties that challenge current models for the formation and early evolution of very low mass objects. In 2010 the team published evidence for unusually strong X-ray emission for FU Tau which allows a detailed study of the accretion and activity properties. Further characterisation of this enigmatic source is in progress (Stelzer, B., Scholz, A., Argiroffi, C., Micela, G., MNRAS, 2010, 408, 1095). In another project focused on the protostellar binary IRAS04326+2512, A. Scholz and his collaborators demonstrated that turbulence plays a major role in driving the fragmentation of the cloud cores to multiple systems, one of the the major open questions in star formation (Scholz, A., Wood, K., Wilner, D., et al., MNRAS, 2010, 409, 1557).

1.2.12 Accretion in Young Stellar Objects

G. Costigan, A. Scholz, T. Ray

The process by which young stars accumulate material from their environment is the focus of the work of PhD student G. Costigan. Based on about 600 high-resolution spectra taken in 2009 and 2010 with the ESO-VLT she has measured the variability in several diagnostics for accretion. She found that accretion rates are mostly stable and vary predominantly on rotational timescales (i.e. a few days). This result puts important limits on models for magnetically controlled accretion and serves as useful guide for future observations.

1.2.13 Rotation in Young Stars

A. Scholz and Others

Rotation is a key parameter in the early evolution of stars. It is controlled by the interaction between stars and disk, magnetically channeled winds, and is intimately linked to the interior changes of stars, which undergoes fundamental changes within the first 100 Myr of their evolution. Understanding the coupling between rotation and magnetic activity may provide constraints for theories on the long-term evolution of the solar activity and thus the Earth's climate, which provides a primary motivation for this research field.

Building on a series of previous publications, A. Scholz has continued his work on the rotational evolution of very low mass stars. Leading a team of researchers from Harvard (USA), Cambridge (UK), Grenoble (France) and Tautenburg (Germany), he has published a new, large sample of rotation periods for stars in the open cluster Praesepe. The study demonstrates that stars with masses below 0.3 solar masses are fast rotators with periods less than 2 days) for at least 600 million years. For comparison, the Sun's rotation period is almost one month. This difference attributed to:

a) the fact that very low mass stars have fully convective interiors in contrast to solar-type stars and

b) their atmospheres are relatively cool which hampers the efficiency of the stellar wind in braking the rotation (Scholz, Irwin, Bouvier, et al., MNRAS, in press).

1.2.14 Observing Outflows Close to the Ejection Engine

D. Coffey, T. Ray, F. Bacciotti (Arcetri), J. Eislöffel (Tautenburg)

Research continued to consolidate findings that jets from young stars rotate, in order to address the issue of how angular momentum is removed during star formation. There are several observational indications that we can indeed observe a rotation signature in jets from young stars. However, there remains some controversy over this interpretation. In particular, in the case of the classical T Tauri star RW Aur, it appears that the direction of the jet rotation is opposite to that of the disk. This paradox must be resolved. Data analysis was conducted on new observations obtained from the Hubble Space Telescope in the near ultraviolet which it is hoped will shed some light on this controversial case.

1.2.15 The Herbig Ae star DK Cha: Accretion and Circumstellar Properties.

R. Garcia Lopez, A. Caratti o Garatti, T. Ray, B. Nisini (Rome), S. Antoniucci (Rome), D. Lorenzetti (Rome), T. Giannini (Rome), J. Eislöffel (Tautenburg)

Very little is known about the properties of the circumstellar material around young and embedded Herbig Ae stars, since they are rare and their nearby circumstellar surroundings are usually hidden from us. Here, we have performed an analysis of the excitation and accretion properties of the young Herbig Ae star DK Cha. The nearly face-on configuration of this source allows us to have direct access to the star-disk system through the excavated envelope and outflow cavity. Based on low-resolution optical and infrared spectroscopy obtained with SOFI and EFOSC2 on the NTT in Chile, we have derived the spectrum of DK Cha from ~0.6 μm to ~2.5 μm. From the detected lines we have investigated the conditions of the gas emitting the HI IR emission lines and have obtained insights into the origin of the other permitted emission lines. In addition, we have derived the mass accretion rate ($\dot{M}_{acc}$)

from the relationships relating the luminosity of the Brγ and Paβ lines with the accretion luminosity (L_{acc}). Numerous forbidden and permitted atomic and molecular emission lines were detected. Some of the permitted emission lines were identified as being excited by fluorescence. Paschen and Brackett decrements were derived and compared with different excitation mechanisms. The Paβ/Brγ ratio is consistent with optically thick emission in LTE at a temperature of ~3500 K, coming from a compact region of ~5 $R_\odot$ of size. The line opacity however decreases in the Br lines from high upper N levels. A good fit to the data is obtained by assuming an expanding gas in LTE, having an electron density at the wind base, $n_e \sim 10^{13}\,cm^{-3}$. In addition, we find that the observed Brackett ratios are very similar to those reported in previous studies of low-mass CTTSs and Class I sources, indicating that these ratios are not dependent on masses and ages. Finally, $L_{acc} \sim 9\,L_\odot$ and $M_{acc} \sim 3\times10^{-8}\,M_\odot yr^{-1}$ values were found, similar those in classical Herbig Ae stars. This indicates that DK Cha is in a final stage of accretion, with an L_{acc}/L_{bol} less than 0.5, or that most of the matter is accumulated in outbursts of accretion that could be responsible for the high variability of the object.

1.2.16 Emission lines as accretion tracers in YSOs: results from an optical-NIR survey of the Chamaleon I and II regions.

S. Antoniucci (Rome), R. Garcia Lopez, B. Nisini (Rome), T. Giannini (Rome), A. Caratti o Garatti, J. Eislöffel (Tautenburg), D. Lorenzetti (Rome), T. Ray, F. Bacciotti (Arcetri), S. Cabrit (Paris), C. Dougados (Grenoble), E. Whelan (Grenoble).

As part of the Poisson spectral survey, we have analysed a sample of 47 sources in the Cha I and II star-forming clouds. The sample was selected from Class I/II objects identified through Spitzer surveys, considering sources with spectral index $\alpha_{2-24\,\mu m} > -1$ and K-band magnitude <12. The data sample consists of low-resolution spectra taken with EFOSC2 and SOFI on the NTT telescope. We have detected many emission lines, commonly observed in YSOs, tracing accretion/wind regions at few AU from the central source and shocks at the base of jets. The large spectral coverage has allowed us to derive the accretion luminosity of the sources using different tracers. For instance, the accretion luminosity was derived using the [OI] 6300Å, Hα, CaII 8542 Å, Paβ and the Brγ lines. The accretion luminosity derived from these tracers present very different levels of scattering for similar values of stellar luminosity, while the one derived from the Brγ line shows the smallest dispersion. In addition, it was found that $L_{acc} < L_*$ over the entire range of stellar luminosities. From the accretion luminosity and stellar parameters the group has also derived the mass accretion rate ($\dot{M}_{acc}$). We found that $\dot{M}_{acc}$ increases with the stellar mass (M_*) by a factor of $M_*^{1.7}$. This value is similar to the one observed in other low-mass star-forming regions, such as Ophiucus and Taurus, while it differs from the one measured for instance in L1641.

1.2.17 Magnetic topologies of late M dwarfs

J. Morin, J.-F. Donati (Toulouse), P. Petit (Toulouse), X. Delfosse (Grenoble), T. Forveille (Grenoble), M. Jardine (St. Andrews)

Fully-convective stars, either main-sequence M dwarfs or T Tauri stars, are challenging objects for stellar dynamo theories. Since they lack a tachocline, i.e. a thin layer of strong shear located at the base of the solar convection zone, magnetic field generation in these objects is likely to rely on processes that differ from solar-type stars. The first spectropolarimetric survey of M dwarfs has already revealed a sharp transition in large-scale magnetic topologies close to the fully convective limit.

The final results of this spectropolarimetric survey of a small sample of active M dwarfs have been released and it focuses on 11 fully convective late M dwarfs (spectral types M5-M8). Tomographic imaging techniques were applied to time-series of circularly polarized profiles of six stars, in order to infer their large-scale magnetic topologies. For three other stars such magnetic maps could not be produced, because of the low variability of the circularly polarized signatures, but we were able to derive some properties of the magnetic fields. For the two remaining objects circular polarization in spectral lines was not detected in individual spectra, although we report a marginal detection for VB 10 by averaging the time-series.

Two distinct categories of magnetic topologies are found: on the one hand strong and steady axisymmetric dipolar fields (similar to mid M dwarfs), and on the other hand weak fields generally featuring a significant non-axisymmetric component, and exhibiting large temporal variations. Comparison with unsigned magnetic fluxes demonstrates that the second category of magnetic fields shows less organization (less energy in the large scales), similar to partly convective early M dwarfs. Stars in both categories have similar stellar parameters, and the data do not show any evidence for a separation between these two categories in the mass-rotation plane. The complex magnetic field recently observed on the low-mass fully convective T Tauri star V2247 Oph could be related to this second group of magnetic topologies.

1.2.18 Dynamo processes in fully convective stars

J. Morin, B. Dintrans (Toulouse)

Direct numerical MHD simulations of dynamo action in fully-convective stars using the PENCIL CODE have been performed in parallel with the spectropolarimetric survey. The primary aim is to assess the effect of stellar rotation on the geometry of the dynamo-generated magnetic field and on differential rotation. First results indicate that for fast rotation a significant axial dipolar component is generated, and that the magnetic field is able to inhibit differential rotation. However, toroidal fields represent a large fraction of the total magnetic energy, in contradiction with spectropolarimetric observations, and the reason for this discrepancy is not yet clear.

1.2.19 Geodynamo results in the stellar context

J. Morin, E. Dormy (ENS Paris), M.Schrinner (ENS Paris), J.-F. Donati (Toulouse)

Despite the very different nature of planetary and stellar interiors, recent studies have strengthened the idea that dynamo generation in rapidly-rotating fully-convective stars, and planets do not fundamentally differ. First, numerical simulations of geodynamo can switch from a steady dipole dominated magnetic field to solar-like dynamo waves simply by changing the aspect ratio of the dynamo region (thick versus thin shell). Secondly, a scaling law for the surface magnetic field strength initially derived from geodynamo simulations and theoretically based on energetics has been shown to be compatible with the observed magnetic fields of Earth and Jupiter as well as fully convective rapidly rotating stars (main sequence M dwarfs and T Tauri stars). We have therefore started to investigate how theories developed in the frame of the geodynamo can reproduce the properties of stellar magnetism in the fully convective regime, in particular two main results of the first spectropolarimetric survey, *i.e.* the sharp transition to dipolar magnetic fields close to the fully-convective boundary and the co-existence of two groups of stars with radically different magnetic fields but having similar stellar parameters.

1.2.20 Modelling non-solar coronae from spectropolarimetric and radio observations

J. Morin, G. Hallinan (Berkeley), M. Jardine (St Andrews), J.-F. Donati (Toulouse)

The recently discovered radio pulses on ultracool dwarfs have been attributed to electron cyclotron maser instability (ECMI) associated with the presence of strong large-scale magnetic fields. Similar pulses have been observed on a fully convective M4 dwarf and are compatible with the large-scale topology extrapolated from Zeeman-Doppler Imaging. Preliminary modelling in this area is now being pursued by us. In particular contemporaneous radio and spectropolarimetric observations allow us to model more accurately the ECMI emission and disentangle pulses from flares. We are also investigating the evolution of the pulses properties in order to assess the potential of radio observations of ECMI emission to study stars out of the reach of spectropolarimetry.

1.2.21 Hydrogen Cyanide and Isocyanide in Prestellar Cores

M. Walmsley, M.Padovani (Barcelona), M.Tafalla (Madrid), P.Hily-Blant (Grenoble), G. Pineau des Forets (Paris)

This research forms part of a systematic investigation of the kinematics and structure of prestellar cores: that is cores with the potential to form stars in that there is approximate balance between thermal pressure gradients and gravitation. We are interested in particular in discovering useful tracers of the densest regions of these cores (above n(H2)=3 $10^4 \mathrm{cm}^{-3}$) where many species and in particular CO deplete onto dust grain surfaces. This research uses IRAM 30m observations to examine 3 nearby cores in Taurus and it has shown that both HCN and HNC remain in the gas phase at higher densities than CO. It has also shown that one can use the 13C substituted versions of these species to confirm recent collision rate calculations.

1.3 The Mid-Infrared Instrument (MIRI) for the James Webb Space Telescope

1.3.1 Background

DIAS is supporting, at the 2 FTE level, test and data analysis software for the Mid-Infrared Instrumet (MIRI) on the James Webb Space Telescope (JWST). The instrument itself is currently being prepared for Flight Model (FM) testing, around the middle of 2011, in the cryo-chamber of the Rutherford Appleton Laboratory and will then be delived to NASA Goddard later that year. The software team is led by Dr. Fred Lahuis from SRON in Groningen and consists of approximately 6 FTEs. The team reports to the MIRI European Consortium (MIRI-EC) at their regular meetings. Software development is in close collaboration with the Space Telescope Science Institute in Baltimore (STScI) using a common environment. The two software developers employed under contract with DIAS effectively starting in 2010 were J. Morin (JM), formerly from the University of Toulouse, and A. Scaife (AS), from the University of Cambridge.

1.3.2 MIRI development environment

A programming language (python) and a first set of libraries have been selected by STScI for the development of JWST calibration and analysis software. It has been decided by the MIRI-EC that new MIRI-specific software developments should use this environment to facilitate their further integration by STScI. JM has identified publicly available compatible software to complete the development environment. This includes science and visualization libraries providing the required functionalities as well as development tools. The development framework for MIRI-EC software developers has been designed and set up. This includes the code repository architecture, documentation and testing framework, reference code examples as well as the software installation procedures for all the supported platforms. This framework ensures that the requirements in terms of code documentation, quality and availability can be fulfilled. The corresponding technical documentation is available online for MIRI-EC and STScI developers and is regularly updated.

1.3.3 Support for simulators and analysis software

JM has been assisting with writing the first two major items of MIRI software developed in the new environment. The performed tasks include software design, python coding, and support for usage of the environment. The first piece of software is SCASim which simulates the response of the MIRI Sensor Chip Array to a given illumination map. It has been adapted from a previous implementation included in SpecSim (the Medium Resolution Spectrometer Simulator), with the aim of providing a unique tool for the simulators developed for the various instrument modes. SCASim is already used to prepare the flight model performance test campaign. The second piece of software is the image reconstruction package described below.

1.3.4 Common tools and data products definition

The various MIRI software components need a number of common tools including various levels of data products (corresponding e.g. to science data for different instrument modes, at different processing levels). JM has designed and implemented first product prototypes, they use the object-oriented paradigm to gather data structure definition, input/output functionalities and specific operations. They are now used by the aforementioned SCA simulator. A second step has consisted in gathering the requirements and first design ideas for the whole set of required data products and to define their level of compatibility with the data types used by softwares designed for the MIRI test campaigns. The design phase for these MIRI data products, as well as the implementation of a prototype system to manage the metadata associated with all types of MIRI data are presently on-going. The generic data products and software tools are available to the MIRI-EC and STScI developers in a package maintained by JM.

1.3.5 Image reconstruction software for the MIRI Imager

AS has been developing a Bayesian image reconstruction package for the MIRI Imager. This package is intended to replace the "Drizzle" image reconstruction method employed to reconstruct undersampled images from multiple offset, or dithered, positions. Initial versions of the new imager were based around a massive inference design which implemented a Maximum Likelihood plus Maximum Entropy minimisation algorithm initially through a Metropolis Hastings MCMC method and later through a Nested Sampling method. The implementation was designed in such a way that additional user defined constraints on image reconstruction, such as sparsity, could be easily incorporated. This algorithm was designed to reconstruct images at "super-resolution", removing the effects of both the pixelization introduced by undersampling, and the convolution from the point spread function of the MIRI optics. The original "Drizzle" algorithm corrects only for the first of these. The methods were implemented in Python in order to be consistent with the MIRI pipeline. After initial testing and consultation with colleagues it was decided that a direct minimisation route would provide a more elegant solution and for this new implementation the powerful MemSys library, provided gratis by MaxEnt Data Consultants for use with MIRI, is currently being linked in to the test version. Substantial reworking of the MemSys I/O is required to perform joint reconstruction of multiple dither frames and this is currently on-going. Once in place the first use of the "MEMDrizzle" imager will be to determine the optimal dither spacing for image reconstruction using simulated data. The original MCMC minimisation code is now being used by colleagues at STScI to investigate the effect of correlated noise on slope fitting for MIRI.

1.4 General Theory

1.4.1 Particle escape from shock acceleration

L. Drury

The escape of charged particles accelerated by diffusive shock acceleration from supernova remnants was shown to be a more complex process than normally appreciated . Using a box model it was shown that the high-energy end of the spectrum can exhibit spectral breaks even with no formal escape as a result of geometrical dilution and changing time-scales. The bulk of the cosmic ray particles at lower energies must be produced and released in the late stages of the remnant's evolution whereas the high energy particles are produced early on; this may explain recent observations of slight compositional variations with energy. [99]

1.4.2 Electron acceleration by plasma shocks

G. Murphy, L. O'C. Drury, M. Dieckmann (U. Linkoping)

The prompt emissions of gamma-ray bursts (GRBs) are seeded by radiating ultrarelativistic electrons. Kinetic energy dominated internal shocks propagating through a jet launched by a stellar implosion, are expected to dually amplify the magnetic field and accelerate electrons. We explore the effects of density asymmetry and of a quasi-parallel magnetic field on the collision of two plasma clouds. We demonstrate how a magnetic field structure resembling the cross section of a flux tube grows self-consistently in the current sheet of the shock transition layer. Plasma filamentation develops behind the shock front, as well as signatures of orthogonal magnetic field striping, indicative of the filamentation instability. These magnetic fields convect away from the shock boundary and their energy density exceeds by far the thermal pressure of the plasma. Localized magnetic bubbles form. Energy equipartition between the ion, electron and magnetic energy is obtained at the shock transition layer. The electronic radiation can provide a seed photon population that can be energized by secondary processes (e.g. inverse Compton). [39, 37]

1.4.3 Nonlinear wave steepening in plasma

G. Murphy, L. O'C. Drury, M. Dieckmann(U. Linkoping)

Nonlinear steepening acoustic waves are potential sources which could seed magnetic field amplification in the interstellar medium. We perform kinetic particle-in-cell simulations of a steepening acoustic wave in 2D. The crest of the wave overtakes the trough, exciting higher harmonics in the nonlinear system. Localized density spikes form. Fast-moving electrons escape from the dense spikes and create a Debye sheath of negative charge around a core of positively charged ions. The sheath degenerates rapidly in a Coulomb explosion (CE) driving a thermal anisotropy which seeds the Weibel instability increasing the magnetic field intensity. Electron phase space tubes are driven away from the explosion site. Such conditions could be useful to seed the further growth of magnetic fields through cosmic-ray driven instabilities.

1.4.4 Filament formation in counterstreaming plasma

G. Murphy, L. O'C. Drury, M. Dieckmann (U Linkoping), G. Sarri, K. Quinn, M. Borghesi (QUB)

The magnetic fields which are inferred in observations of gamma ray bursts and supernova remnants can originate from plasma effects. 2D particle simulations model the filamentation instability. Our results show that exponential growth is followed by saturation of the magnetic field. The composition of the beams affects the growth of the electrostatic field and the in-plane current coherency and correlation scale. The growth rate is close to the analytical value of $\beta\sqrt{2/\Gamma_b}$. The hypothesis that two-stream instability can contribute to breakup of filaments is confirmed by numerical simulation.

1.4.5 Large scale magnetic fields in viscous resistive accretion disks

G. Murphy, J. Ferreira (Laboratoire d'Astrophysique de Grenoble), C. Zanni (U. Torino)

Cold steady-state disk wind theory from near Keplerian accretion disks requires a large scale magnetic field at near equipartition strength. However the minimum magnetization has never been tested. We investigate the time evolution of an accretion disk threaded by a weak vertical magnetic field. The strength of the field is such that the disk magnetization falls off rapidly with radius. Numerical simulations of viscous resistive accretion disk are performed using the magnetohydrodynamic code PLUTO. The large scale magnetic field introduces only a small perturbation to the disk structure, with accretion driven by the dominant viscous torque. A super fast magnetosonic jet is observed to be launched from the innermost regions and remains stationary over more than 900 Keplerian orbits. Ejection is made possible because the magnetization reaches unity at the disk surface, due to the steep density decrease. However, no ejection is reported when the midplane magnetization becomes too small. The asymptotic jet velocity remains nevertheless too low to explain observed jets due to the negligible power carried away by the jet. Astrophysical disks with superheated surface layers could drive analogous outflows even if their midplane magnetization is low. Sufficient angular momentum would be extracted by the turbulent viscosity to allow the accretion process to continue. The magnetized outflows would be no more than byproducts, rather than a fundamental driver of accretion. However, if the midplane magnetization increases towards the center, a natural transition to an inner jet dominated disk could be achieved.

1.4.6 Computational studies of ISM turbulence

T. Downes (DIAS/DCU), S.O'Sullivan (DIT)

Observations of molecular clouds indicate that they are turbulent. This turbulence is dynamically significant and may well affect both the overall evolution of molecular clouds as well as the progress of star formation within these clouds. However, the properties of turbulence in such clouds is not well understood. Although much work has been done on studying turbulence in these clouds under the assumption of ideal magnetohydrodynamics we know that multifluid effects are important on scales of less than a parsec or so.

In collaboration with Prof Alexander Lazarian (Univ Wisconsin, USA) initial studies on the so-called resurrection of turbulence at small scales in multifluid MHD systems were undertaken. Initial results appear to suggest that this affect may be reproducible in our numerical simulations and work on this is ongoing.

The second phase of a comprehensive study of the decay of multifluid MHD turbulence in molecular clouds using HDYRA was submitted to ApJ in late 2010. It showed that, as expected from previous work, multifluid effects enhance the rate of decay of turbulence and decreases the amount of structure present in the mass distribution on small scales. Interestingly, it would appear that the gross features of multifluid turbulence can be modeled rather well by approximating the influence of the multifluid effects by spatially and temporally constant resistivities.

Finally, 3 million core hours on the JUGENE system were obtained under the DEISA DECI-6 call to perform simulations of driven, multifluid MHD turbulence. This will allow us to investigate the statistical steady state of such turbulence. This is of considerable importance as it is generally believed that turbulence in molecular clouds is continually driven by some, as yet unknown, process and hence the dynamical influence of turbulence on processes such as star formation can only be understood by such studies.

1.4.7 The multifluid MHD Kelvin-Helmholtz instability

A. Jones (DCU), T. Downes (DCU/DIAS)

AJ submitted her PhD thesis on the multifluid MHD KH instability. The main focus of the thesis is an in-depth study of the influence of multifluid effects on the behaviour of the KH instability in weakly ionised plasmas with particular reference to molecular clouds.

It was found that non-ideal effects do not alter the linear regime of the instability. However, at saturation the magnetic energy in the system is considerably reduced by the presence of ambipolar diffusion and, indeed, the system returns to a quasi-steady state more quickly when this effect is important. On the other hand, if the Hall effect dominates the non-ideal effects then strong dynamo action is observed and the system does not return to a quasi-steady state at any point.

1.4.8 The petascale multifluid MHD code HYDRA

T. Downes (DCU/DIAS)

Previous work involving PRACE prototype testing led to TD being invited by PRACE to present on his experiences at the prestigious ISC'10 conference in Hamburg. In addition, Cray Inc licensed the multifluid MHD HYDRA code from TD, via DCU, in order to help to profile the performance of their systems with a petascale code. This resulted in a collaborative effort between TD and Cray Inc to gain an understanding of the interaction of the HYDRA code with the Cray environment.

1.5 Miscellaneous

1.5.1 Space Dosimetry - DOBIES and Theseus

D. O'Sullivan

The ESA Prodex Meeting was held at Enterprise Ireland, Dublin 3 on April 13th and D O'Sullivan reported on the latest results from the DOBIES Project. Analysis of data acquired on the Space Shuttle flight 13S in 2008 was completed and confirmed the early results reported last year. The project is now finished [58].

D O'Sullivan continued as a member of the European Science Foundation Theseus Project (`http://www.theseus-eu.org`) and attended the first meeting of the Space Radiation Expert Group (April 6th-9th) at Sasbachwalden, Germany. He contributed to the first draft of a major ESF publication on space radiation with special emphasis on the dosimetry of heavy cosmic ray nuclei and solar events. This project is due to continue until late 2011.

1.5.2 The Magnetic Universe

A. Scaife

AS is part of the management team for the LOFAR Magnetism Key Science Project (MKSP). This KSP aims to investigate fundamental astrophysical questions on the distribution of magnetic fields in the Universe in order to understand the origin of cosmic magnetism. Polarimetry with LOFAR will allow investigations of the so far unexplored domain of extremely weak magnetic field strengths via Faraday rotation. This is a large international project with contributions from 12 countries. AS has also been heavily involved in the formation of the Irish LOFAR consortium (I-LOFAR) and is a primary contributor to the white paper.

AS is leading the "polarized sky" working group of the MeerKAT International GigaHertz TierEd Extragalactic (MIGHTEE) Survey, accepted as a key survey for the South African MeerKAT telecope, and is also a member of the survey executive committee. This is a wide-area deep continuum survey in the Southern hemisphere which will use the alignment of intrinsic polarization angles and large-scale structure to investigate the problem of cosmic bi-refringence.

AS is PI of the BEOWULF: B-field Estimation and Observational Wide-field Understanding of Large-scale Faraday-structure Survey for the Apertif telescope which is Phased Array Feed (PAF) pathfinder instrument for the SKA telescope. This project will use finely spaced rotation measure grids to constrain the magnetic field strengths in filaments of inter-cluster gas in the Perseus-Pisces supercluster of galaxies with a view to determining the origin of cosmic magnetism. This survey has passed the first round of reviews and will face a second round in early 2011.

AS is an invited member of the European SKA Science Working Group (ESSWG) and has been nominated as Magnetism Co-ordinator. In this role she will be responsible for collating and drafting the magnetism science case for Phase I of the SKA.

1.5.3 The Sunyaev–Zel'dovich Effect

A. Scaife

AS leads the Galactic science program for the AMI telescope (UK) and is part of the consortium for the blind SZ cluster survey being carried out with this instrument. SZ cluster surveys will provide an important constraint on the structure formation of the Universe, which is not well understood from CMB cosmology. 2010 has seen the first wave of SZ science from the AMI telescope as well as a first blind detection of new SZ structure. AS has been involved in both the analysis of SZ data and of the 10C survey of high frequency radio sources, which is the deepest high frequency radio survey of significant extent by over two orders of magnitude in completeness.

AS is leading a follow-up programme of high resolution SZ measurements with the MUSTANG camera on the GBT to the Planck satellite new cluster detections catalogue. This project is in collaboration with colleagues in the US and the UK.

2 Invited talks

- Aya Bamba
  1. “Are dark particle accelerators really DARK?”, GeV to TeV Connection, Ringberg, 11-16, January
  2. “X-ray measurement of particle injection and escape from SNR shocks”, Exploring Supernova Remnants and Pulsar Wind Nebulae in X-rays: before and after ASTRO-H, Kanagawa, 18-19, February
  3. “Cosmic ray production in Supernovae and SNR”, IXO Science Meeting, Paris, 27-29, April
  4. “SNR study with CTA”, CTA General Collaboration Meeting, Oxford, 9-11 November
- Anna Scaife
  1. “Anomalous Microwave Emission from Spinning Dust: Current Observational Evidence”, University of Groningen, 23 April
  2. “The Arcminute Microkelvin Imager”, University of Oxford, 12 July
  3. “Spinning Dust: Review”, Workshop on Hyper-Compact HII Regions, CSIRO Sydney, 7 September
  4. “Cosmic Magnetism with Next Generation Telescopes”, European SKA Science Working Group, Cambridge, 9 December
- Luke Drury
  1. “High acceleration efficiency versus thermal heating in SNRs" Invited talk at JAXA workshop, Tokyo, 18 Feb.
  2. “The origin of the Galactic cosmic rays - what clues do we have and how close to a solution are we?” Invited review at COSPAR session E18, Bremen, 20 Jul.
  3. “Escaping the Accelerator: How, When, How Many?” Invited talk at ICATPP Conference on Cosmic Rays for Particle and Astroparticle Physics, Como, Italy, 8 Oct.
  4. “Particle acceleration theory” Invited plenary talk at 25th Texas Symposium on Relativistic Astrophysics, Heidelberg, 10 Dec.
- Felix Aharonian
  1. “Gamma-ray sources and magnetic fields”, Bern, Switzerland, Large-scale magnetic fields in the Universe (01.03.-05.03.2010)
  2. “Cosmic Rays and gamma-ray astronomy from the ground”, Catania, Italy, CRIS 2010: “100 years of Cosmic Ray Physics: from pioneering experiments to physics in space” (13.09.- 17.09.2010)
  3. “Very High Energy Source Populations”, Cape Town, South Africa, 5th International Conference on Beyond the Standard Models of Particle Physics, Cosmology and Astrophysics (01.02.-06.02.2010)
  4. “HTRA with Cerenkov Telescopes”, Crete, Greece, High Time Resolution Astrophysics (HTRA) IV (05.05.-07.05.2010)

5. “High Energy Sources above 10 MeV”, Dublin, Ireland, 8th INTEGRAL Workshop: The Restless Gamma-ray Universe (27.09-30.09.2010), also Durham, England, European Conference
6. “Overview of recent observations of very high energy gamma-rays”, Moscow, Russia, HEA-2010: High Energy Astrophysics (21.12.-24.12.2010)
7. “On the origin of very hard spectra of TeV blazars”, Trieste Italy, SCINEGHE 2010, Gamma-ray Astrophysics in the Multimessenger context (08.09.-10.09.2010)
8. “Sources of highest energy cosmic rays, intergalactic magnetic fields, and formation of extended gamma-ray structures”, Nice, France, Non-thermal phenomena in colliding galaxy clusters (15.11-18.11 2010)

- Valenti Bosch-Ramon
  1. “Review of microquasar modeling and future directions”, 38th COSPAR assemly, Germany, July
  2. “Non-thermal processes in microquasars”, IAU Symposium 275: Jets at all Scales, Argentina, September
  3. “Extragalactic astrophysical sources of gamma-rays”, 8a Reunión de la Sociedad Española de Astronomía, Spain, September
  4. “Gamma-rays from black-hole binaries”, Accretion and Outflow in Black Hole Systems, Nepal, October
  5. “Theoretical review of Gamma-ray binaries”, ISSI meeting on gamma-ray binaries, Switzerland, November
  6. “Radiation absorption and reprocessing: cascading and secondary synchrotron emission”, Variable galactic gamma-ray sources, Germany, December
- A. Caratti o Garatti
  1. “Investigating Class I sources: real youth or make-up?”, Dublin Institute for Advanced Studies, 17 June
  2. “Corona Australis observed with IRAC and MIPS”, Spitzer Gould Belt Survey Meeting, Dublin (23-27/8/2010), 23 Aug.
- R. Garcia Lopez
  1. “NIR diagnostics of Class I protostars: the jets”, Max Planck Institut für Radioastronomie, Bonn, Germany, 16 June
- J. Morin
  1. “Exploring the magnetic topologies of cool stars”, IAUS 273, Ventura, USA, 24 Aug.
  2. “Observations of magnetic topologies across the fully convective threshold”, Cool Stars XVI, Seattle, USA, 1 Sept.
  3. “Magnétisme stellaire à travers la limite entièrement convective”, Programme National de Physique Stellaire, Marseille, France, 7 Oct.
- T. Ray

1. “Jets and Outflows from Brown Dwarfs”, University of New South Wales, Sydney, Australia, 16 Feb.
2. “Outflows from Young Stars and Brown Dwarfs”, University of Canterbury, Christchurch, New Zealand, 25 Feb.
3. “The Mid-Infrared Instrument (MIRI) on the James Webb Space Telescope”, Enterprise Ireland, 13 April
4. “The Potential of Exploring SN1987A with MIRI”, Ringberg Castle, Bavaria, Germany, 21 October

3 Externally funded projects and grants of resources

3.1 Observing Runs: Completed or Awarded in 2010

- A detailed study of Class I YSOs in CrA. Apr-Sept. 2010 - 19 hrs at VLT (ISAAC). A. Caratti o Garatti, R. Garcia Lopez, S. Antoniucci (INAF-OAR), D.E. Peterson (CfA), B. Tyler (CfA), Barreyre L., and Ray T.
- An REM/TNG study of IR variability in embedded Young Stellar Objects. Aug 2010 - Jan 2011 - 4 hrs + 96 hrs at TNG/REM, service. A. Caratti o Garatti, F. Massi (INAF-OAA), R. Garcia Lopez, B. Nisini (INAF-OAR), A. Scholz, S. Antoniucci (INAF-OAR), T. Giannini (INAF-OAR), D. Coffey, T. Ray
- An REM/Spitzer survey of the optical/IR variability of Young Stellar Objects in Serpens. Apr 2011 - May 2011, 30 hrs at REM, service. A. Caratti o Garatti, K. Covey (Uni. Cornell) , R. Garcia Lopez, A. Scholz, J. Stauffer (SSC-CALTECH), M. Morales-Calderon (SSC-CALTECH), L. Rebull (CALTECH), R. Gutermuth (Five Col.)
- HST Program Title: Investigation of Jet Rotation in Young Stars via High Resolution UV Spectra. Aug 2010 - Feb 2011 - 18 Orbits of HST PI/CoI: *F. Bacciotti (Arcetri), D. Coffey, J. Eislöffel (Tautenburg), T. Ray*
- Nov-Dec 2010: 5 nights at Calar Alto Observatory (2.2m/CAFOS), PI/CoI: A. Scholz (DIAS), J. Eisloeffel (Tautenburg), B. Stelzer (Palermo), G. Costigan (DIAS)
- Nov 2010: 1 night at Subaru Telescope (FMOS), PI/CoI: A. Scholz (DIAS), K. Muzic (Toronto), R. Jayawardhana (Toronto), M. Tamura (Tokyo)
- May 2010: 2 nights at Subaru Telescope (FMOS), PI/CoI: A. Scholz (DIAS), K. Muzic (Toronto), R. Jayawardhana (Toronto), M. Tamura (Tokyo)
- Jan 2010: 6 nights at INT (MOSAIC), PI/CoI: A. Scholz (DIAS), J. Irwin (Harvard), S. Hodgkin (Cambridge), J. Bouvier (Grenoble), J. Eisloeffel (Tautenburg)
- Jan 2010: 6 nights at CTIO/Blanco (MOSAIC), PI/CoI: A. Scholz (DIAS), J. Irwin (Harvard), S. Hodgkin (Cambridge), J. Bouvier (Grenoble), J. Eisloeffel (Tautenburg)
- 13 hours at Herschel (PACS/SPIRE) awarded for 2011, PI/CoI: A. Scholz (DIAS), A. Natta (Florence), L. Testi (ESO), G. Meeus (Madrid), R. Jayawardhana (Toronto), J. Greaves (St. Andrews), Kenneth Wood (St. Andrews), A. Brandeker (Stockholm)

- GBT (16hr) Characterization of anomalous emission in extra-galactic HII regions (PI: Murphy; co-I: Scaife)
- ATCA (40hr) Anomalous microwave emission from spinning dust in circumstellar disks (PI: Scaife)
- Effelsberg (40hr) Characterization of spinning dust in Galactic HII regions (AGE HII programme; PI: Scaife)
- GBT (14hr) Characterization of spinning dust in Galactic HII regions (AGE HII programme; PI: Scaife)
- LOFAR (multiple runs) Polarization commissioning (PI: Beck; co-I: Scaife)

3.2 Current Research Project Grants

- Luke Drury
  1. PRTLI-4 e-INIS, Project Coordinator
  2. SFI RFP, one postdoc
- Felix Aharonian
  1. EU FP6 Design Study KM3NeT, 40K, Preparatory Phase 30K
  2. SFI RFP, two postgrads
  3. EU Marie Curie Fellowship
- Tom Ray
  1. PRODEX MIRI, two scientific officers
  2. SFI RFP, one postdoc and one postgrad
  3. IRCSET, two postdocs
  4. Lindsay Scholarship (DIAS & Armagh Observatory), one postgrad
- Aleks Scholz
  1. RFP10/AST2780 (1 postgraduate student)
- Denis O'Sullivan (emeritus)
  1. DOBIES - from Enterprise Ireland under PRODEX, 24k over 2 years

3.3 Proposals submitted

- L. Drury (with A. Shearer, NUIG, and J. Morrison, UCC)
  - SFI PI2010 call "Data Centric Computing" (unsuccessful)
- G Murphy
  - European Research Council starter grant "Shocks: Understanding Relativistic Plasma Acceleration Systems" (pending)

4 Contributions to Teaching

- F. A. Aharonian
  - 40th Saas-Fee Lecture Series: Astrophysics at Very High Energies (10 lectures), Les Diablerets, Switzerland, March 15-20, 2010
- E. J. A. Meurs
  - Course of 4th year lectures on High Energy Astrophysics, DCU.
  - Supervision of three final year undergraduate research projects in DCU
- D. Coffey
  - Introduction to Gravitation & Relativity, 1 semester, NUI, Maynooth
- T. Ray
  - Astronomy and Astrophysics (PY1P10), 1st Year, 1 semester, TCD
  - Stellar and Galactic Structure (PY3A03), 3rd Year, 1 semsester, TCD
  - PhD Viva, H. Wheelwright, University of Leeds, 17 December
- A. Scholz & T. Ray
  - Supervision of Final Year Astrophysics Project, "Accretion in Young Stars", 1 semester, Sarah Killeen, TCD
- M. Chernyakova
  - Module on High-Energy Astrophysics, Loughborough University, UK

5 Community Service, Awards and Distinction

- Luke Drury:
  1. Member of the ICHEC oversight board;
  2. Member of the H.E.S.S. Collaboration Board;
  3. Member of the Council of the RIA (until 16th March)
  4. Member of the Grid-Ireland board
  5. Honorary Andrews' Professor of Astronomy, TCD
- Felix Aharonian:
  1. Adjunct Professor in the School of Physics UCD
  2. co-PI of the ROTSE project;
  3. member of the H.E.S.S. Collaboration Board;
  4. member of the Consortium of the KM3NeT;
  5. member of the working group "Science with NeXT" (Japanese next generation X-ray mission);

6. member (“Principal Scientist/Professor”) of the Heidelberg Graduate School of Fundamental Physics at the University of Heidelberg;
7. Adjunct Professor of the International Center for Relativistic Astrophysics Network, Pescara/Rome
8. external scientific member of the MPIK in the High Energy Astrophysics Group
9. co-director of LEA - European Associated Laboratory on High Energy Astrophysics (jointly supported by CNRS and MPG);
10. member of the European Astronet Infrastructure Roadmap Panel A: “High energy, astroparticle astrophysics and gravitational waves";
11. member of the International Review Panel of the Helmholtz Association: "Astroparticle Physics"
12. an Editor of the International Journal of Modern Physics D.

- Evert Meurs:
  1. member of the REM consortium;
  2. member of the RIA Astronomy and Space Science Committee;
  3. member of the Space Strategy Working Group (Space Industry Skillnet);
  4. Adjunct Professorship Dublin City University;
- Tom Ray
  1. Co-PI of the MIRI project;
  2. Member of the e-MERLIN Steering Committee (Steering committee for national radio astronomy facilities in the UK);
  3. Robert Ball Professorship Trinity College Dublin;
  4. Member of the Herschel Observatory Time Allocation Committee;
  5. Member of the Physical and Chemical Sciences Committee, Royal Irish Academy
  6. Member of the European MIRI Steering Committee (an ESA committee)
  7. Member of the Gogarty Scholarship Committee to assist students attend the international Space Studies Program or complete a M.Sc. in Space Studies or Space Management
  8. Member of the Management Committee of Armagh Observatory
- Masha Chernyakova
  1. Member of the XMM-Newton AO-10 proposal review panel.
- Denis O’Sulllivan
  1. Member of the expert panel at the Chief Scientific Adviser’s Office. He was commissioned to review the present status of the possible health effects of exposure to electromagnetic fields from power lines and produce a position paper on behalf of the Office. The paper, which was published on the Office’s website concluded that such effects were scientifically unconvincing and that they were impossible according to well established physics and biological principles.

6 Contributions to research infrastructures

Advanced research in Astronomy and Astrophysics nowadays increasingly relies on access to advanced observing facilities and also to an advanced computational e-infrastructure. In fact for its observational work the section relies entirely on access to international resources such as the space observatories Chandra, Fermi and the Hubble Space Telescope and shared international facilities on the ground such as the European HESS consortium gamma-ray telescopes in Namibia as well as major ground-based optical and radio facilities. At European level the section is a member of two major projects identified in the European Strategic Forum for Research Infrastructures roadmap, the next-generation Cherenkov Telescope Array project (CTA) and the KM3NeT project for neutrino astronomy and has an interest in the radio projects LOFAR and SKA. During the year L. Drury attended meetings of the Irish ESFRI participants to brief the national representatives on CTA and KM3NeT.

The need for an accompanying advanced e-infrastructure was the main motivation for proposing the PRTLI-4 funded project e-INIS which aims to establish on a pilot basis an integrated national e-infrastructure bringing together advanced networking, high-performance computing, and high-capacity data services. During the year the first user-controlled light path connections were lit on the Irish Research Optical Network and demonstrated to sustain 10Gb/s throughput. In addition to providing research infrastructure, the e-INIS project has delivered improved levels of expert user-support and facilitated access to shared ICT resources. A key challenge with such shared services is that of user authentication, which the e-INIS Edugate activity has sought to address. Edugate provides a federated identity management system for all national researchers and has this year successfully transitioned from pilot to full production status. The main national computational resource, Stokes, which was the first significant capital investment under the project in 2008, was this upgraded and extended with direct contributions from five national universities further strengthening the provision of shared services in Ireland. With ever increasing volumes of data, both as the raw material and by-product of research, its storage, management and sharing has become an integral component of modern e-Infrastructures. The first phase of the federated national data-store was further advanced this year with a capacity approaching one Petabyte. Researchers from a broad spectrum of disciplines have become early adopters of the data management services and have already begun to fully exploit the available storage and network bandwidth capacity. The BlueGene computer systems Schroedinger and Lanczos, operated on behalf of the National Capability Computing Consortium by the Institute, reached their planned three-year life at the end of the year. An evaluation of the impact of the systems concluded that they had exceeded expectations and been a major factor in propelling Ireland and Irish researchers into the field of true capability computing. An impressive demonstration of this was the success of Turlough Downes, working in the Section on secondment from DCU, in obtaining proto-type testing access on two of the largest supercomputers in Europe for his Hydra code.

7 Public Outreach

Outreach events focused on the use of Dunsink as a public observatory and location for meetings. An extensive programme of redecoration and renovation in Observatory House was carried out over the Summer months at a time when it caused minimal disruption to the outreach activities and the buildings are now in much better condition. Table 1 lists the main outreach events that tool place during the year. The popular scheme of inviting a primary school to visit Dunsink during the day and a secondary school during the evening was followed again in science week 2010.

Table 1: Dunsink events in 2010

Date	Event	Principal Speaker or Participants
18th Jan	Sky viewing event	IAS Members
04th Feb	Public Open Night	Paul Dempsey (Creme/Dias)
15th Feb	Software instruction IAS	Michael Murphy IAS
17th Feb	Public Open Night	Masha Chernyakova
22th Feb	Practical Telescope Instruction	John Murphy IAS
24th Feb	UCD Mature Student	Peter Duffy UCD
03rd Mar	Public Open Night	Anna Scaife
10th Mar	Public Open Night	Deirdre Kelleghan
24th Mar	Irish language evening	Colin Melody
01st Apr	TCD Physics sociiety	Peter Gallagher TCD
16th Apr	Sky viewing event	Ronald Buta IAS
17th Apr	International Speaker	Ronald Buta IAS
26th Apr	Software instruction	Michael Murphy IAS
05th May	Public Open Night	John Flannery SCD Astronomy
10th May	AGM IAS	IAS members
12th May	TCD retreat day	TCD graduate students
12th Jun	Solarfest	TCD/IFAS
16th Jun	Astronomy Badge Event	Various
17th Sep	IFAS Social Evening	Michael O'Connell
16th Oct	Hamilton/Maths Event	Nui Maynooth, DIAS
18th Oct	Teaching the Sky	John O'Neill IAS
20th Oct	Public Open Night	David Malone NUIM
22th Oct	International Young People's Star Party	Masha Chernyakova
03rd Nov	Public Open Night	Perikles Rammos
08th Nov	Secondary School D13	Paul Dempsey (Creme)
09th Nov	St Killian D14	Denys Malshev
09th Nov	E-Inis meeting	E-Inis members
09th Nov	Hartstown Community	Gareth Murphy
10th Nov	Holy Child Boys	Julien Morin
10th Nov	TCD Solar Group TY's	TCD
10th Nov	Girl Guide group	Aleks Scholz
11th Nov	Holy Child Boys	Grainne Costigan
11th Nov	Parents/Childs Evening	Alessio Caratti O Garatti
12th Nov	Holy Child N/S	Rebeca Garcia Lopez
12th Nov	IAS Jupiter Watch	Telescope Viewing Evening
17th Nov	Public Open Night	Aleks Scholz
18th Nov	South County Dublin	John Murphy IAS
20th Nov	O'Raifeartaigh family event	Una Ni Raifeartaigh
13th Dec	NUI Maynooth	Fiona Mc Groarty DIT
14th Dec	IAS Meeting	Michael Murphy IAS
15th Dec	Public Open Night	Paul Dempsey (Creme)

8 Conferences Organised

- F. A. Aharonian and A. Bamba held an international meeting "Exploring Supernova Remnants and Pulsar Wind Nebulae in X-rays: before and after ASTRO-H", at ISAS/JAXA, Japan, Feb. 18–19, which attracted more than 70 participants.
- F. A. Aharonian, V. Bosch Ramon, D. Khangulyan organised a workshop in Heidelberg, Germany, on "Variable Galactic Sources" (30.11.-03.12.2010)
- F. A. Aharonian was chair of the local organising committee for the 25th TEXAS Symposium on Relativistic Astrophysics held in Heidelberg, Germany (06.12.-12.12.2010).
- A. Caratti o Garatti, E. Flood and T. Ray organised a Spitzer Gould Belt Team Meeting, DIAS, 10 Burlington Road, Dublin, 23 - 27 August.
- A. Scaife organised a meeting of the LOFAR Magnetism Key Science Project in 10 Burlington Road, Dublin, 26-27 October.

9 Detailed Bibliography of Publications

Note that where possible hyperlinks have been provided to the journal article and preprint version.

9.1 Peer-reviewed Publications in 2010

[1] F. Acero et al. "First detection of VHE γ-rays from SN 1006 by HESS". In: A&A 516 (June 2010), A62+. DOI: 10.1051/0004-6361/200913916. arXiv:1004.2124 [astro-ph.HE].

[2] F. Acero et al. "Localizing the VHE γ-ray source at the Galactic Centre". In: MNRAS 402 (Mar. 2010), pp. 1877–1882. DOI: 10.1111/j.1365-2966.2009.16014.x. arXiv:0911.1912 [astro-ph.GA].

[3] F. Aharonian and A. M. Taylor. "Limitations on the photo-disintegration process as a source of VHE photons". In: *Astroparticle Physics* 34 (Dec. 2010), pp. 258–266. DOI: 10.1016/j.astropartphys.2010.08.004. arXiv:1005.3230 [astro-ph.HE] (cit. on p. 6).

[4] F. Aharonian et al. "Discovery of VHE γ-rays from the BL Lacertae object PKS 0548-322". In: A&A 521 (Oct. 2010), A69+. DOI: 10.1051/0004-6361/200912363. arXiv:1006.5289 [astro-ph.HE].

[5] F. A. Aharonian, S. R. Kelner, and A. Y. Prosekin. "Angular, spectral, and time distributions of highest energy protons and associated secondary gamma rays and neutrinos propagating through extragalactic magnetic and radiation fields". In: Phys. Rev. D 82.4 (Aug. 2010), pp. 043002–+. DOI: 10.1103/PhysRevD.82.043002. arXiv:1006.1045 [astro-ph.HE] (cit. on p. 7).

[6] T. Anada et al. "X-Ray Studies of HESS J1809−193 with Suzaku". In: PASJ 62 (Feb. 2010), pp. 179–. arXiv:0912.1931 [astro-ph.HE].

[7] D. Arzoumanian et al. "The contribution of star-spots to coronal structure". In: MNRAS 410 (Feb. 2011), pp. 2472–2480. DOI: 10.1111/j.1365-2966.2010.17623.x. arXiv:1008.3613 [astro-ph.SR].

[8] A. Bamba, K. Mori, and S. Shibata. "Chandra View of Pulsar Wind Nebula Tori". In: ApJ 709 (Jan. 2010), pp. 507–511. DOI: 10.1088/0004-637X/709/1/507. arXiv:0912.1103 [astro-ph.HE].

[9] A. Bamba et al. "X-ray Evolution of Pulsar Wind Nebulae". In: ApJ 719 (Aug. 2010), pp. L116–L120. DOI: 10.1088/2041-8205/719/2/L116. arXiv:1007.3203 [astro-ph.HE].

[10] M. V. Barkov, F. A. Aharonian, and V. Bosch-Ramon. "Gamma-ray Flares from Red Giant/Jet Interactions in Active Galactic Nuclei". In: ApJ 724 (Dec. 2010), pp. 1517–1523. DOI: 10.1088/0004-637X/724/2/1517. arXiv:1005.5252 [astro-ph.HE] (cit. on p. 6).

[11] M. Benisty et al. "The 2008 outburst in the young stellar system Z CMa. I. Evidence of an enhanced bipolar wind on the AU-scale". In: A&A 517 (July 2010), pp. L3+. DOI: 10.1051/0004-6361/201014776. arXiv:1007.0682 [astro-ph.EP].

[12] E. Bressert et al. "The spatial distribution of star formation in the solar neighbourhood: do all stars form in dense clusters?" In: MNRAS 409 (Nov. 2010), pp. L54–L58. DOI: 10.1111/j.1745-3933.2010.00946.x. arXiv:1009.1150 [astro-ph.SR].

[13] S. Casanova et al. "Modeling the Gamma-Ray Emission Produced by Runaway Cosmic Rays in the Environment of RX J1713.7−3946". In: PASJ 62 (Oct. 2010), pp. 1127–1134. arXiv:1003.0379 [astro-ph.HE] (cit. on p. 4).

[14] S. Casanova et al. "Molecular Clouds as Cosmic-Ray Barometers". In: PASJ 62 (June 2010), pp. 769–. arXiv:0904.2887 [astro-ph.HE] (cit. on p. 4).

[15] M. S. Clemens et al. "Starburst evolution: free-free absorption in the radio spectra of luminous IRAS galaxies". In: MNRAS 405 (June 2010), pp. 887–897. DOI: 10.1111/j.1365-2966.2010.16534.x. arXiv:1002.3334 [astro-ph.GA].

[16] D. Coffey et al. "Hydrogen Permitted Lines in the First Near-IR Spectra of Th 28 Microjet: Accretion or Ejection Tracers?" In: ApJ 719 (Aug. 2010), pp. 505–514. DOI: 10.1088/0004-637X/719/1/505. arXiv:1006.5400 [physics.space-ph].

[17] S. Covino et al. "Challenging gamma-ray burst models through the broadband dataset of GRB 060908". In: A&A 521 (Oct. 2010), A53+. DOI: 10.1051/0004-6361/201014994. arXiv:1007.4769 [astro-ph.HE].

[18] R. M. Crocker et al. "γ-rays and the far-infrared-radio continuum correlation reveal a powerful Galactic Centre wind". In: MNRAS 411 (Feb. 2011), pp. L11–L15. DOI: 10.1111/j.1745-3933.2010.00983.x. arXiv:1009.4340 [astro-ph.GA].

[19] C. del Burgo, C. Allende Prieto, and T. Peacocke. "PHASES: a concept for a satellite-borne ultra-precise spectrophotometer". In: *Journal of Instrumentation* 5 (Jan. 2010), pp. 1006–+. DOI: 10.1088/1748-0221/5/01/P01006. arXiv:1001.1879 [astro-ph.IM].

[20] V. D'Elia et al. "Non-variability of intervening absorbers observed in the UVES spectra of the 'naked-eye' GRB080319". In: MNRAS 401 (Jan. 2010), pp. 385–393. DOI: 10.1111/j.1365-2966.2009.15648.x. arXiv:0906.3191 [astro-ph.CO].

[21] M. E. Dieckmann et al. "Particle-in-cell simulation of a mildly relativistic collision of an electron-ion plasma carrying a quasi-parallel magnetic field . Electron acceleration and magnetic field amplification at supernova shocks". In: A&A 509 (Jan. 2010), A89+. DOI: 10.1051/0004-6361/200912643.

[22] J.-F. Donati et al. "Complex magnetic topology and strong differential rotation on the low-mass T Tauri star V2247 Oph". In: MNRAS 402 (Mar. 2010), pp. 1426–1436. DOI: 10.1111/j.1365-2966.2009.15998.x. arXiv:0911.1080 [astro-ph.SR].

[23] J.-F. Donati et al. "Magnetospheric accretion and spin-down of the prototypical classical T Tauri star AA Tau". In: MNRAS 409 (Dec. 2010), pp. 1347–1361. DOI: 10.1111/j.1365-2966.2010.17409.x. arXiv:1007.4407 [astro-ph.SR].

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