Astronomy and Astrophysics Research Report 2009

Presented in draft form to the Governing Board
of the School of Cosmic Physics
on 15 February 2010,
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Contents

1 Highlights

In 2009 the combined Astronomy and Astrophysics Section has:

- been praised for the international quality of its research by the quinquennial external peer review of the School;
- published 55 refereed publications with a further 10 preprints submitted and 29 non-referreed articles;
- elucidated the mode of formation of the so-called “elephant trunks” seen in star-forming regions using advanced computational simulations;
- confirmed long-standing theoretical expectations with the detection of the star-burst galaxy NGC 253 as a HESS source;
- joined the Japanese Astro-H consortium;
- begun work on the MIRI software development;
- deployed the first stage of the e-INIS national data store and lambda-switched interconnect;
- obtained 4.3 million core-hours of computing time under the PRACE proto-type testing programme to run the HYDRA code;
- obtained funding for and ordered a new 3D projection system to enhance the Dunsink open night experience;
- hosted an international workshop on radiation hazards associated with the international space station.

2 Staff

Senior Professors Luke Drury, Evert Meurs

Professors Felix Aharonian, Tom Ray

Emeritus Professors Denis O'Sullivan, Alex Thompson, Ian Elliott, Tao Kiang[1]

Honorary Professor of Computational Science Jean-Christophe Desplat, Associate Director of ICHEC

Schroedinger Fellows Andy Lim (to 30 Nov), Carlos del Burgo (to 30 Sep), Masha Chernyakova, Aya Bamba (from 1 Nov) Aleks Scholtz (from 1 Nov)

EU Marie Curie Fellow Stefano Gabici (to 30 Sep)

JETSET Project Positions Emma Whelan (academic administrator until 28 Feb), Jose Gracia (researcher until 31Jan), Perikles Rammos (until 31 Jan)

IRCSET Fellows Deirdre Coffey, Paul Dempsey (to 28 Aug), Linda Podio (to 16 Dec), Emma Whelan (from 1 Sep)

SFI-funded Researchers Alessio Caratti o Garatti (from 12 Jan), Gareth Murphy (from 15 Jan)

EI-funded Researchers Julien Morin (from 9 Nov), Anna Scaife (from 1 Dec)

Visiting Scientists Mark Dieckmann (Norköping University, Sweden), Turlough Downes (on secondment from DCU), Dirk Froebrich (University of Kent), Rebeca Garcia Lopez (Rome Observatory), Jason Kirk (University of Cardiff), Subu Mohanty (Imperial College London), Antonella Natta (Arcetri Observatory, Florence), Malcolm Walmsley (Arcetri Observatory, Florence).

Hamilton Scholars Sean Delaney, Jonathan Mackey, Denys Malyshev, Lisa Fallon, Laure Barreyre, Nakisa Nooraee

Lindsay Scholar (jointly with Armagh Observatory) Gráinne Costigan (from 1 Oct)

Experimental Officer (IT support unit) Stephane Dudzinski

Senior Technical Officer (Dunsink Observatory) Mike Smyth

Technical Officers Anne Grace, Hilary O'Donnell, Eileen Flood

Secretarial and Reception Phyllis Daly, two vacancies

IT support Philippe Grange

Groundsman (Dunsink Observatory) Tomás Ó Gríofa

e-INIS project coordinator and outreach officer Keith Rochford

JETSET project positions Emma Whelan (academic administrator, to 28 Feb), Jose Gracia (researcher, to 31 Jan), Perikles Rammos (database architect, to 31 Jan)

[1] Obit 3 Apr 2009

Research Associates Dr Peter Duffy, UCD; Professor A Lawrence FRSE, Royal Observatory Edinburgh; Professor Brian McBreen, UCD; Dr VF Polcaro, Istituto di Astrofisica Spaziale; Dr Mark Wilkinson, Institute of Astronomy, University of Cambridge; Dr Laura Norci, DCU; Dr Brian Espey, TCD; Dr Matthew Redman, NUIG; Dr Justin Donnelly, DIT; Mr Brendan Jordan; Dr Gareth Murphy, Grenoble; Dr Stephen O'Sullivan, UCD; Dr Dazhuang Zhou, Houston; Mr John Walsh, TCD; Dr Brenda Frye, DCU (from 5 Sep).

3 Research Reports

3.1 High-Energy Astrophysics

Felix A. Aharonian

My research activity is focused on topics of High Energy Astrophysics with an emphasis on the phenomenological and theoretical studies of multi-wavelength properties of cosmic gamma-ray sources. A significant fraction of my research is related, in one way or another, to observations of very high energy gamma-ray sources with the HESS array of imaging atmospheric Cherenkov telescopes, and interpretation of these data. I am also collaborating closely with the Japanese Suzaku X-ray mission team (ISAS, Tokyo), as well as with the NANTEN team (Nagoya University) on CO observations of the interstellar medium; both wavelength domains are of great importance for identification and understanding of the nature of very high energy gamma-ray sources. In the so-called hadronic scenarios, gamma-radiation is accompanied by the production of high energy neutrinos. This motivates my involvement in projects related to high energy neutrino astronomy, in particular in the context of design studies of the cubic-kilometer-volume underwater neutrino detector in the Mediterranean Sea (KM3NeT). I am also a member of the ROTSE-III collaboration studying the optical properties of prompt gamma-ray burst afterglows. Finally, I am selected by the European Space Agency (ESA) as a representative of ESA in the science working group of the future JAXA-NASA X-ray mission ASTRO-H. The main topics of my research conducted in 2009 are described below.

3.1.1 Nonthermal Radiation of Young Supernova Remnants

Zirakashvili, V. N.; Aharonian, F. A. The Astrophysical J., vol. 708, pp. 965-980 (2009); eprint arXiv:0909.2285

A new numerical code, designed for the detailed numerical treatment of nonlinear diffusive shock acceleration, is used for modeling of particle acceleration and radiation in young supernova remnants. 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. We model the energy spectra and spatial distributions of nonthermal emission of the young supernova remnant RX J1713.7-3946 and compare the calculations with the spectral and morphological properties of this object obtained in broad energy band from radio to very high energy gamma-rays. We discuss 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, respectively. We discuss also a "composite" scenario 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.

3.1.2 Broad-band non-thermal emission from molecular clouds illuminated by cosmic rays from nearby supernova remnants

Gabici, S.; Aharonian, F. A.; Casanova, S. Monthly Notices of the Royal Astronomical Society, vol. 396, pp. 1629-1639 (2009)

Molecular clouds are expected to emit non-thermal radiation due to cosmic ray interactions in the dense magnetized gas. Such emission is amplified if a cloud is located close to an accelerator of cosmic rays and if energetic particles can leave the accelerator site and diffusively reach the cloud. We consider here a situation in which a molecular cloud is located in the proximity of a supernova remnant which is efficiently accelerating cosmic rays and gradually releasing them in the interstellar medium. We calculate the multiwavelength spectrum from radio to gamma rays which is emerging from the cloud as the result of cosmic ray interactions. The total energy output is dominated by the gamma-ray emission, which can exceed the emission in other bands by an order of magnitude or more. This suggests that some of the unidentified TeV sources detected so far, with no obvious or very weak counterparts in other wavelengths, might be in fact associated with clouds illuminated by cosmic rays coming from a nearby source. Moreover, under certain conditions, the gamma-ray spectrum exhibits a concave shape, being steep at low energies and hard at high energies. This fact might have important implications for the studies of the spectral compatibility of GeV and TeV gamma-ray sources.

3.1.3 Revisiting the diffuse neutrino flux from the inner Galaxy using new constraints from very high energy γ -ray observations

Taylor, A.; Gabici, S.; White, R.; Casanova, S.; Aharonian, F. NIMPA, vol. 602, pp. 113-116 (2009)

Following the MILAGRO collaborations recent publication of the detection of diffuse multi-TeV emission from a region close to the inner Galaxy, we revisit the diffuse neutrino flux calculation from this region. Conventional models following cosmic ray (CR) propagation through the Galaxy, tuned to reproduce the locally observed CR spectrum, give rise to diffuse fluxes that are significantly below the detected diffuse flux. Assuming that this excess is hadronic in origin and is representative of the whole inner Galactic region, we estimate the expected diffuse neutrino flux from a region of the Galactic disk with coordinates $-40 < l < +40$. The diffuse flux of neutrinos, for this hadronic only scenario, is found to be detectable by a km-scale detector located in the northern hemisphere.

3.1.4 A Peculiar Jet and Arc of Molecular Gas toward the Rich and Young Stellar Cluster Westerlund 2 and a TeV Gamma Ray Source

Fukui, Y.; Furukawa, N.; Dame, T.; Dawson, J.; Yamamoto, H.; Rowell, G.; Aharonian, F.; Hofmann, W.; de OŰa Wilhelmi, E.; Minamidani, T.; Kawamura, A.; Mizuno, N.; Onishi, T.; Mizuno, A.; Nagataki, S. PASJ, vol.61, pp.L23–L27 (2009)

We have discovered remarkable jet- and arc-like molecular features toward the rich and young stellar cluster Westerlund 2. The jet has a length of ≈ 100 pc and a width of ≈ 10 pc, while the arc shows a crescent shape with a radius of ≈ 30 pc. These molecular features each have masses of $\approx 10^4 M_\odot$, and show spatial correlations with the surrounding lower density H I gas. The jet also shows an intriguing positional alignment with the core of the TeV gamma-ray source HESS J1023-575 and with the MeV/GeV gamma-ray source recently reported by the Fermi collaboration. We argue that the jet and arc are caused by an energetic event in Westerlund 2, presumably due to an anisotropic supernova explosion of one of the most massive member stars. While the origin of the TeV and GeV gamma-ray sources is uncertain, one may speculate that they are re-

lated to the same event via relativistic particle acceleration by strong shock waves produced at the explosion or by remnant objects, such as a pulsar wind nebula or a microquasar.

3.1.5 Molecular Clouds as Cosmic-Ray Barometers

Casanova, S.; Aharonian, F.; Fukui, Y.; Gabici, S.; Jones, D. ; Kawamura, A.; Onishi, T.; Rowell, G.; Torii, K.; Yamamoto, H. Submitted to PASJ, eprint arXiv:0904.2887 (2009)

It is generally assumed that the flux of cosmic-rays observed at the top of the Earth's atmosphere is representative of the flux in the Galaxy at large. The advent of high sensitivity, high resolution gamma-ray detectors, together with a knowledge of the distribution of the atomic hydrogen and especially of the molecular hydrogen in the Galaxy on sub-degree scales, as provided by the NANTEN survey, creates a unique opportunity to explore the flux of cosmic rays in the Galaxy. We present a methodology which aims to provide a test bed for current and future gamma-ray observatories to explore the cosmic ray flux at various positions in our Galaxy. In particular, for a distribution of molecular clouds and local cosmic ray density as measured at the Earth, we estimate the expected GeV to TeV gamma-ray signal, which can then be compared with observations. An observed gamma-ray flux less than predicted would imply a CR density in specific regions of the Galaxy less than that observed at Earth, and vice versa. The methodology presented will profit from the upcoming gamma-ray data from the Fermi observatory and from future very high resolution, very high energy telescopes.

3.1.6 Acceleration and radiation of ultra-high energy protons in galaxy clusters

Vannoni, G.; Aharonian, F. A.; Gabici, S.; Kelner, S. R.; Prosekin, A. submitted to Astronomy & Astrophysics (2009) eprint arXiv:0910.5715)

Clusters of galaxies are believed to be capable to accelerate protons at accretion shocks to energies exceeding 10^18 eV. At these energies, the losses caused by interactions of cosmic rays with photons of the Cosmic Microwave Background Radiation (CMBR) become effective and determine the maximum energy of protons and the shape of the energy spectrum in the cutoff region. The aim of this work is the study of the formation of the energy spectrum of accelerated protons at accretion shocks of galaxy clusters and of the characteristics of their broad band emission. The proton energy distribution is calculated self-consistently via a time-dependent numerical treatment of the shock acceleration process which takes into account the proton energy losses due to interactions with the CMBR. We calculate the energy distribution of accelerated protons, as well as the flux of broad-band emission produced by secondary electrons and positrons via synchrotron and inverse Compton scattering processes. We find that the downstream and upstream regions contribute almost at the same level to the emission. For the typical parameters characterizing galaxy clusters, the synchrotron and IC peaks in the spectral energy distributions appear at comparable flux levels. For an efficient acceleration, the expected emission components in the X-ray and gamma-ray band are close to the detection threshold of current generation instruments, and will be possibly detected with the future generation of detectors.

3.1.7 HESS J0632+057: A New Gamma-Ray Binary?

Hinton, J. A.; Skilton, J. L.; Funk, S.; Brucker, J.; Aharonian, F. A.; Dubus, G.; Fiasson, A.; Gallant, Y.; Hofmann, W.; Marcowith, A.; Reimer, O. The Astrophysical Journal Letters, vol. 690, pp. L101-L104 (2009)

The High Energy Stereoscopic System (HESS) survey of the Galactic plane has established the existence of a substantial number ($\approx$ 40) of Galactic TeV γ-ray sources, a large fraction of which remain unidentified. HESS J0632+057 is one of a small fraction of these objects, which is point-like in nature ($< 2'$rms), and is one of only two point-like sources that remain unidentified. Follow-up observations of this object with XMM-Newton have revealed an X-ray source coincident with the TeV source and with the massive star MWC 148, of the spectral type B0pe. This source exhibits a hard spectrum, consistent with an absorbed power law with $\Gamma = 1.26 \pm 0.04$, and shows significant variability on hour timescales. We discuss this spatial coincidence and the implied spectral energy distribution of this object and argue that it is likely a new γ-ray binary system with a close resemblance to the three known members of this class and, in particular, to LS I +61 303. Further, X-ray, radio, and optical observations of this system are needed to firmly establish HESS J0632+057 as a new member of this rare class of Galactic objects.

3.1.8 The radio counterpart of the likely TeV binary HESSJ0632+057

Skilton, J.; Pandey-Pommier, M.; Hinton, J.; Cheung, C.; Aharonian, F.; Brucker, J.; Dubus, G.; Fiasson, A.; Funk, S.; Gallant, Y.; Marcowith, A.; Reimer, O. Monthly Notices of the Royal Astronomical Society, vol. 399, pp. 317-322 (2009)

The few known γ-ray binary systems are all associated with variable radio and X-ray emission. The TeV source HESSJ0632+057, apparently associated with the Be star MWC148, is plausibly a new member of this class. Following the identification of a variable X-ray counterpart to the TeV source we conducted Giant Metrewave Radio Telescope (GMRT) and Very Large Array (VLA) observations in 2008 June-September to search for the radio counterpart of this object. A point-like radio source at the position of the star is detected in both 1280-MHz GMRT and 5-GHz VLA observations, with an average spectral index, $\alpha \approx 0.6$. In the VLA data there is significant flux variability on month time-scales around the mean flux density of about $0.3'rmmJy$. These radio properties (and the overall spectral energy distribution) are consistent with an interpretation of HESSJ0632+057 as a lower power analogue of the established γ-ray binary systems.

3.1.9 Study of the Spectral and Temporal Characteristics of X-Ray Emission of the Gamma-Ray Binary LS 5039 with Suzaku

Takahashi, T. Kishishita, T.; Uchiyama, Y.; Tanaka,T.; Yamaoka, K.; Khangulyan, D.; Aharonian, F.; Bosch-Ramon, V.; Hinton, J.A The Astrophysical Journal, vol. 697, pp. 592-600 (2009)

We report on the results from Suzaku broadband X-ray observations of the galactic binary source LS 5039. The Suzaku data, which have continuous coverage of more than one orbital period, show strong modulation of the X-ray emission at the orbital period of this TeV gamma-ray emitting system. The X-ray emission shows a minimum at orbital phase 0.1, close to the so-called superior conjunction of the compact object, and a maximum at phase 0.7, very close to the

inferior conjunction of the compact object. The X-ray spectral data up to 70 keV are described by a hard power law with a phase-dependent photon index which varies within $\Gamma \simeq 1.45 - 1.61$. The amplitude of the flux variation is a factor of 2.5, but is significantly less than that of the factor 8 variation in the TeV flux. Otherwise the two light curves are similar, but not identical. Although periodic X-ray emission has been found from many galactic binary systems, the Suzaku result implies a phenomenon different from the "standard" origin of X-rays related to the emission of the hot accretion plasma formed around the compact companion object. The X-ray radiation of LS 5039 is likely to be linked to very high energy electrons which are also responsible for the TeV gamma-ray emission. While the gamma rays are the result of inverse Compton (IC) scattering by electrons on optical stellar photons, X-rays are produced via synchrotron radiation. Yet, while the modulation of the TeV gamma-ray signal can be naturally explained by the photon-photon pair production and anisotropic IC scattering, the observed modulation of synchrotron X-rays requires an additional process, the most natural one being adiabatic expansion in the radiation production region.

3.1.10 X-ray observations of PSR B1259-63 near the 2007 periastron passage

Chernyakova, M.; Neronov, A.; Aharonian, F.; Uchiyama, Y.; Takahashi, T. Monthly Notices of the Royal Astronomical Society, vol. 397, pp. 2123-2132 (2009)

PSR B1259-63 is a 48-ms radio pulsar in a highly eccentric 3.4-yr orbit with a Be star SS 2883. Unpulsed γ-ray, X-ray and radio emission components are observed from the binary system. It is likely that the collision of the pulsar wind with the anisotropic wind of the Be star plays a crucial role in the generation of the observed non-thermal emission. The 2007 periastron passage was observed in unprecedented details with Suzaku, Swift, XMM-Newton and Chandra missions. We present here the results of this campaign and compare them with previous observations. With these data we are able, for the first time, to study the details of the spectral evolution of the source over a 2-month period of the passage of the pulsar close to the Be star. New data confirm the pre-periastron spectral hardening, with the photon index reaching a value smaller than 1.5, observed during a local flux minimum. If the observed X-ray emission is due to the inverse Compton (IC) losses of the 10-MeV electrons, then such a hard spectrum can be a result of Coulomb losses, or can be related to the existence of the low-energy cut-off in the electron spectrum. Alternatively, if the X-ray emission is a synchrotron emission of very high-energy electrons, the observed hard spectrum can be explained if the high-energy electrons are cooled by IC emission in Klein-Nishina regime. Unfortunately, the lack of simultaneous data in the TeV energy band prevents us from making a definite conclusion on the nature of the observed spectral hardening and, therefore, on the origin of the X-ray emission.

3.1.11 Looking Into the Fireball: ROTSE-III and Swift Observations of Early Gamma-ray Burst Afterglows

Rykoff, E. et al The Astrophysical Journal, vol. 702, Issue 1, pp. 489-505 (2009)

We report on a complete set of early optical afterglows of gamma-ray bursts (GRBs) obtained with the Robotic Optical Transient Search Experiment (ROTSE-III) telescope network from 2005 March through 2007 June. This set is comprised of 12 afterglows with early optical and Swift/X-

Ray Telescope observations, with a median ROTSE-III response time of 45 s after the start of γ-ray emission (8 s after the GCN notice time). These afterglows span 4 orders of magnitude in optical luminosity, and the contemporaneous X-ray detections allow multi-wavelength spectral analysis. Excluding X-ray flares, the broadband synchrotron spectra show that the optical and X-ray emission originate in a common region, consistent with predictions of the external forward shock in the fireball model. However, the fireball model is inadequate to predict the temporal decay indices of the early afterglows, even after accounting for possible long-duration continuous energy injection. We find that the optical afterglow is a clean tracer of the forward shock, and we use the peak time of the forward shock to estimate the initial bulk Lorentz factor of the GRB outflow, and find $100 < \Gamma < 1000$, consistent with expectations.

3.1.12 Centaurus A as TeV γ-ray and possible UHE cosmic-ray source

Rieger, F. M.; Aharonian, F. A. Astronomy and Astrophysics, vol. 506, pp. L41-L44 (2009)

The most nearby active galaxy Cen A has attracted considerable attention as a detected TeV gamma-ray and possible ultra-high energy (UHE) cosmic-ray emitter. Aims: We investigate the efficiency of particle acceleration close to the supermassive black hole (BH) horizon assuming that accretion in the innermost part of the disk occurs in an advection-dominated (ADAF) mode. Methods: We analyze the constraints on the achievable particle energies imposed by radiative losses and corotation for conditions inferred from observations. Results: We show that for an underluminous source such as Cen A, centrifugally accelerated electrons may reach Lorentz factors of up to $\Gamma > 10^7$, allowing inverse Compton (Thomson) up-scattering of ADAF sub-mm disk photons into the TeV regime with an associated maximum (isotropic) luminosity of the order of a few times $10^{39}\,\mathrm{erg\,s^{-1}}$. Up-scattering of Comptonized disk photons is expected to lead to a TeV spectrum with a spectral index 1.5-1.9, consistent with HESS results. The corresponding minimum variability timescale could be as low as $r_\mathrm{L}/c \approx 1\,\mathrm{h}$ for a typical light cylinder radius of $r_\mathrm{L} \approx 5 r_s$. While efficient electron acceleration appears to be well possible, protons are unlikely to be accelerated into the extreme UHECR regime close to the central black hole. We argue that if Cen A is indeed an extreme UHECR emitting source, then shear acceleration along the kpc-scale jet could represent one of the most promising mechanisms capable of pushing protons up to energies beyond 50 EeV.

3.1.13 Spectral shape and photon fraction as signatures of the Greisen-Zatsepin-Kuzmin cutoff

Taylor, Andrew M.; Aharonian, Felix A. Physical Review D, vol. 79, Issue 8, id. 083010 (2009)

With the prospect of measuring the fraction of arriving secondary photons, produced through photo-pion energy-loss interactions of ultra-high-energy cosmic ray (UHECR) protons with the microwave background during propagation, we investigate how information about the local UHECR source distribution can be inferred from the primary (proton) to secondary (photon) ratio. As an aid to achieve this, we develop an analytic description for both particle populations as a function of propagation time. Through a consideration of the shape of the Greisen-Zatsepin-Kuzmin cutoff and the corresponding photon fraction curve, we investigate the different results expected for

both different maximum proton energies injected by the sources, as well as a change in the local source distribution following a perturbative deformation away from a homogeneous description. At the end of the paper, consideration is made as to how these results are modified through extragalactic magnetic field effects on the proton's propagation. The paper aims to demonstrate how the shape of the cosmic ray flux in the cutoff region, along with the photon fraction, are useful indicators of the cutoff origin as well as the local UHECR source distribution.

3.1.14 Very High Energy Gamma Rays from $e^{\pm}$ Pair Halos

Eungwanichayapant, A.; Aharonian, F. International Journal of Modern Physics D, vol. 18, pp. 911-927 (2009)

We study the formation of giant electron-positron pair halos around the powerful high energy extragalactic sources, in particular active galactic nuclei. We investigate the dependence of radiation of pair halos, in particular the spectral and angular distributions on the energy spectrum of the primary gamma rays, the redshift of the source, and the flux of the extragalactic background light.

3.1.15 Development of the ASTRO-H satellite

Aya Bamba, Felix Aharonian

ASTRO-H is a next generation X-ray satellite currently under construction in Japan. Aya Bamba and Felix Aharonian have joined the ASTRO-H mission to contribute to both the hardware development and the science case study. Aya Bamba has a responsibility to minimise the effects of out-gassing in the satellite and has begun to design the out-gas shield for the X-ray CCDs on ASTRO-H. She is also the leader for the public outreach programme 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. As part of the science case studies and to promote awareness of ASTRO-H an international meeting "Exploring Supernova Remnants and Pulsar Wind Nebulae in X-rays: before and after ASTRO-H" will be held at ISAS/JAXA, Japan, in Feb 2010 organised by F. Aharonian and A. Bamba.

3.1.16 X-ray follow-ups of TeV sources

Aya Bamba, Takayasu Anada (ISAS/JAXA), Ryoko Nakamura (ISAS/JAXA), Yoshitomo Maeda (ISAS/JAXA), Jacco Vink (Utrecht U.), et al.

We have made X-ray follow-up observations of TeV sources to point out their origin and emission mechanism. HESS J1809−193 has been recognized as a pulsar wind nebula (Anada, Bamba, et al., PASJ, in press), whereas W28, an old SNR detected by HESS, showed us that the north-eastern shock just hit a giant molecular cloud (Nakamura, Bamba, et al., PASJ, submitted). From Cas A, the youngest SNR in our Galaxy, we found that synchrotron X-rays mainly comes from the reverse shock (Maeda et al., PASJ, 61, 1217), which is also bright in TeV gamma-rays. Magnetars are energetic sources in the X-ray band, and recently some people claims that magnetars could be TeV gamma-ray emitters. Vink and Bamba (2009, ApJL, 707, 148) discovered nebula around a magnetar for the first time, which will be an important key to understand the nature of magnetars.

3.1.17 Study of gamma-ray loud binaries in the Fermi era

M.Chernyakova, A. Neronov (ISDC), D. Malyshev

γ-ray-loud binary systems (GRLB) are a newly identified 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) γ-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 γ-ray emitters. Most of the variable and transient Galactic sources of GeV γ-ray are expected to belong to the GRLB class.

With the launch of the Fermi it becomes possible to complete the multi wavelength spectrum of GRLBs with the data in GeV domain. Two of γ-ray-loud binaries, LSI +61° 303 and LS 5039, turned out to be bright in GeV energy domain. In both binaries a spectral cutoff at several GeV has been detected. Our studies of the LSI +61° 303 behaviour at different wave length showed that the effect of $\gamma-\gamma$ pair production can not explain the cutoff at GeV energies and the difference in the orbital modulation of the source flux at GeV and TeV energies, and that one has to consider a possibility that GeV and TeV γ -rays are produced via different mechanisms (e.g. synchrotron and inverse Compton) and/or by different particle populations (e.g. electrons and protons). One of the main observational evidence proving the hadronic model of source activity would be a detection of the neutrino signal from the source. In our work we worked out firm predictions for the expected neutrino signal from the source in this case.

We have also started a project aimed to study in detail variable sources of GeV emission located in the galactic plane, as these sources has a big chance to belong to still puzzling and unrepresentative GRLB class.

3.1.18 INTEGRAL hard X-ray spectra of the cosmic X-ray background and Galactic ridge emission

M. Chernyakova, M. Turler (ISDC), A. Neronov (ISDC)

We derive the spectra of the cosmic X-ray background (CXB) and of the Galactic ridge X-ray emission (GRXE) in the 20-200 keV range from the data of the IBIS instrument aboard the INTEGRAL satellite obtained during the four dedicated Earth-occultation observations of early 2006. We analyse the modulation of the IBIS/ISGRI detector counts induced by the passage of the Earth through the field of view of the instrument. Unlike previous studies, we do not fix the spectral shape of the various contributions, but model instead their spatial distribution and derive for each of them the expected modulation of the detector counts. The spectra of the diffuse emission components are obtained by fitting the normalizations of the model lightcurves to the observed modulation in different energy bins. The obtained CXB spectrum is consistent with the historic HEAO-1 results and falls slightly below the spectrum derived with Swift/BAT. A 10% higher normalization of the CXB cannot be completely excluded, but it would imply an unrealistically high albedo of the Earth. The derived spectrum of the GRXE confirms the presence of a minimum around 80 keV with improved statistics and yields an estimate of $\approx 0.6\,M_\odot$ for the average mass of white dwarfs in the Galaxy. The analysis also provides updated normalizations for the spectra of the Earth's albedo and the cosmic-ray induced atmospheric emission.

3.2 Theory

Luke Drury

3.2.1 Particle-in-cell simulations of mildly relativistic plasma collisions

Gareth Murphy, L Drury, M Dieckmann

The acceleration of particles by mildly relativistic shocks requires plasma effects to inject a seed population of electrons. Particle-in-cell (PIC) codes have been successful in modelling plasmas but are computationally expensive. We ported the particle-in-cell code PSC code to ICHEC BlueGene/L and Altix ICE architecture and modified the code to allow for inline data analysis and parallel data output. We were awarded a total of 205,000 hours core time for the project from ICHEC. We carried out successful large-scale simulations of magnetised mildly relativistic plasma collisions which show promising results for magnetic field amplification (ten times that expected from shock compression) and electron acceleration to Lorentz factors of ≈ 200. We showed that filamentation is not suppressed by a quasi-parallel magnetic field. We also found evidence for decay of filaments into magnetic bubbles. See Fig 1 for a snapshot from one of the simulation runs.

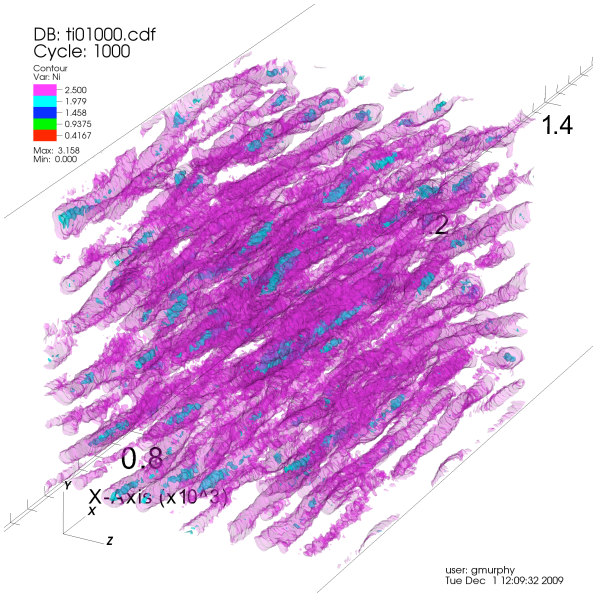

Figure 1: The Figure shows three-dimensional filaments formed by Weibel-type instabilities in a magnetised plasma shock. The filaments mix and merge in three dimensions and amplify the local magnetic field, enabling emission of synchrotron radiation.

3.2.2 How cold can Supernova Remnants be?

L. O'C. Drury, F. A. Aharonian, D. Malyshev, S. Gabici Astron. and Astrophys. (2009) 496 1-6.

Multiwavelength observations of supernova remnants can be explained within the framework of the diffusive shock acceleration theory, which allows effective conversion of the explosion energy into cosmic rays. Although the models of nonlinear shocks describe reasonably well the nonthermal component of emission, certain issues, including the heating of the thermal plasma and the related X-ray emission, remain still open. To discuss how the evolution and structure of supernova remnants is affected by strong particle acceleration at the forward shock analytical estimates were combined with detailed discussion of the physical processes. The overall dynamics is shown to be relatively insensitive to the amount of particle acceleration, but the post-shock gas temperature can be reduced to a relatively small multiple, even as small as six times, the ambient temperature with a very weak dependence on the shock speed. This is in marked contrast to pure gas models where the temperature is insensitive to the ambient temperature and is determined by the square of the shock speed. It thus appears to be possible to suppress ef-

fectively thermal X-ray emission from remnants by strong particle acceleration. This might provide a clue for understanding the lack of thermal X-rays from the TeV bright supernova remnant RX J1713.7-3946.

3.2.3 Comparison of *Ansätze* for semi-analytic models of non-linear particle acceleration in shocks

Luke Drury, Elena Amato (Arcetri)

As part of the programme of work of the Kavli Institute for Theoretical Physics workshop on particle acceleration in astrophysical plasmas it was decided to directly compare the various approximate *Ansätze* that have been proposed in semi-analytic treatments of steady non-linear shock acceleration. The differences are remarkably small, and early indications are that the more sophisticated models are little better, and in some cases worse, than the simpler ones, contrary to expectation.

3.2.4 Computational studies of ISM turbulence

T. Downes, S.O'Sullivan (DCU)

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.

The first phase of a study of the decay of multifluid MHD turbulence in molecular clouds using the HYDRA code was published in early 2009 and showed that multifluid effects cause turbulence to decay more rapidly. They also reduce the number of small-scale density structures within the cloud produced by the turbulence. The former result implies that, in order to maintain the level of turbulence observed, the driving source must supply energy at a greater rate. This study has been continued and is now nearly complete. The results support the conclusions of the first phase. Plans are now being made to perform simulations of driven multifluid MHD turbulence to investigate the statistical properties of clouds subject to this kind of turbulence for comparison with observations.

3.2.5 PRACE prototype supercomputer testing

T. Downes

As part of a Europe-wide competition, 4.3 million core hours were awarded by PRACE (see `http://www.prace-project.eu/`) to investigate the performance of three different supercomputing architectures using the HYDRA multifluid MHD code. This award amounted to 95% of all the time awarded in that competition. HYDRA was shown to scale well to petascale systems on the JUGENE Blue Gene/P system at FZ-Juelich. Excellent performance was also found on the Bull Nehalem system JuROPA at FZ-Juelich, despite some technical system issues with running very large jobs. FZ-Juelich has given T. Downes an ongoing account on JuROPA to perform a joint study to resolve these issues. The performance of the Cray XT5 system at CSC in Finland was somewhat disappointing and Cray Inc have since contacted T. Downes to begin a joint study to pin-point the source of the poor performance.

Following from the success of HYDRA on the

JUGENE system, IBM invited T. Downes to make a presentation at the Blue Gene Consortium meeting held at SC09 in Portland, Oregon. DIAS has also been invited to formally join the Blue Gene Consortium.

3.3 Star Formation

Tom Ray

3.3.1 Brown Dwarf Outflow Studies

E. Whelan, L. Podio, T.P. Ray with F. Bacciotti (Arcetri) and S. Randich (Arcetri)

Spectroscopic studies have strongly supported the assertion that protostellar accretion and outflow activity persist to the lowest masses. Observations to date have concentrated on studying the forbidden emission line (FEL) regions of young brown dwarfs and in all cases data have been collected using the UV-Visual Echelle Spectrometer (UVES) on the ESO Very Large Telescope. Because these outflows are so faint, and most of the emission is within the 'seeing disk', we have to resort to the special technique of spectro-astrometry to recover information on milli-arcsecond scales. Application of the method, using orthogonal slits, allows us to recover 2-D spatial data. In particular the brown dwarf ISO-Oph 32 was shown to drive a blueshifted outflow with a radial velocity of 10-20 km s^{-1} at a position angle of 240° ± 7°. Another brown dwarf, ISO-ChaI 217 was found to have a bipolar outflow (with radial velocities of Ð20 km s^{-1} and +40 km s^{-1}) and a position angle of around 200°. A striking feature of the ISO-ChaI 217 outflow is the strong asymmetry between the red- and blue-shifted lobes. This asymmetry is revealed in the relative brightness of the two lobes (the redshifted lobe is brighter), the factor of 2 difference in radial velocity (the redshifted lobe is faster) and the difference in the electron density (again higher in the red lobe). Such asymmetries are common in jets from low-mass protostars and the observation of a marked asymmetry at such a low masses supports the idea that brown dwarf outflow activity is scaled down from low-mass protostellar activity.

Studies of mass loss rates for our sample of brown dwarf outflows show these to be comparable to the mass accretion rates. This result however is preliminary as it relies on a small sample and the proxies for accretion in brown dwarfs may not be as reliable as those in classical T Tauri stars.

3.3.2 First Detection of Acceleration and Deceleration in Protostellar Jets

A. Caratti o Garatti

For the first time a multi-epoch (20 year baseline) kinematical investigation of a number of Herbig-Haro (HH) objects has been achieved. Optical and near-IR narrow-band imaging, along with medium (optical) and high resolution (NIR) spectroscopic analysis, have been used to probe the kinematical and physical changes in outflows over time. By means of multi-epoch and multi-wavelength narrow-band images, we derived proper motions (hence tangential velocities), and flux variability of the knots. Radial velocities and physical parameters of the gas were derived from spectroscopy. Finally, spatial velocities and inclination of the flows were obtained by combining both imaging and spectroscopy. In 20 years, about 60% of the observed knots show some degree of flux variability. For the first time acceleration and deceleration in protostellar jets are detected. Our set of observations apparently indicates acceleration and deceleration in a variety of knots along the jets. For about 20% of the knots, mostly coincident with

working surfaces or interacting knots along the flows, a significant change in both flux and velocity is observed. We argue that such changes are related and that all, or part, of the kinetic energy lost by the interacting knots is successively radiated. Several knots are deflected and this is likely the result of the flow colliding with a dense cloud or with clumps.

3.3.3 Simulations of Interacting Herbig-Haro objects and Comparison with Observations

F. De Colle (now Lick Observatory, formerly DIAS) and A. Caratti o Garatti

We are investigating protostellar jet time-variability using 2-D axisymmetric magneto-hydrodynamic (MHD) simulations. In particular, we wish to reproduce the emission and velocity variability, observed in interacting knots along the jets. To understand the process responsible for such changes, the simulations are carried out by periodically pulsing the jet and comparing the results obtained with observations. In our simulations, the variability is assumed to be due to the interaction between knots traveling with different shock speeds and densities.

3.3.4 NIR Spectroscopic Survey of Jets from Massive Young Stellar Objects

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

The detection and study of jets and outflows from high-mass young stellar objects (HMYSOs) is of primary importance in understanding the mechanism which produces massive stars. Using the 4.5 μm excess (IRAC, band 2) as a tracer of shocked H_2, we have identified about 160 candidate protostellar outflows in the Spitzer GLIMPSE survey. In order to verify their nature, a follow-up campaign for H_2 1–0 S1 (2.12 μm) imaging has been carried out. using different IR detectors (ESO-NTT/SofI, TNG/NICS, ARC-3.5m/NICFPS). About half of the observed targets have been detected at 2.12 μm. The non-detections point to large dust column densities and/or different excitation conditions. Additionally, we undertook an unbiased spectroscopic follow-up of the H_2 emissions 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 (temperature, extinction), and the flow properties (mass, mass ejection rate, H_2 luminosity), correlating them with the evolutionary stage of the driving YSO. The analysis has not yet been completed.

3.3.5 YSO NIR Spectral Survey: L1641 Star Forming Region

A. Caratti o Garatti, L. Barreyre, and T. Ray in collaboration with Rome and Tautenburg Observatories

Our classification of young stellar objects (YSOs) is empirical, based on the Spectral Energy Distribution (SED). Recent studies revealed the limitations of such a classification, which does not provide any information on the physical properties of the protostar itself, as well as on the processes related to the accretion/ejection activity, occurring in the circumstellar environment. Additionally, such empirical 'miss-classification' can introduce huge errors in determining the lifetimes associated with the various stages of YSO evolution. A correct classification can be obtained from a large sample of objects, combining the YSO SEDs analysis with their mass accretion rates, derived from spec-

troscopy. We have thus started an optical and infrared spectroscopic survey, using the ESO/NTT and SOFI, of YSOs located in six nearby molecular clouds of the Gould Belt (a star formation ring centred roughly on the Sun). These spectra are complementary to the SEDs derived from Spitzer, 2MASS, and optical photometry. In particular, the DIAS group is studying the YSO sample in L1641 star forming region.

3.3.6 Spitzer Gould Belt Survey: Corona Australis Star Formation Region

A. Caratti o Garatti, T.P. Ray and the Spitzer Gould Belt Team

We have investigated 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. We have identified and classified 40 young stellar objects (YSOs) in CrA through Spitzer and near-infrared 2MASS photometry. In addition we have used multi-epoch H_2 maps, which allowed us to detect jets and outflows, studying their proper motions, and identifying their exciting sources.

3.3.7 Constraining the Inventory of Star Forming Regions and the Initial Mass Function

A. Scholz, R. Jayawardhana (Univ. Toronto), V. Geers (Univ. Toronto), D. Froebrick (Univ. Kent), C.J. Davis (Joint Astronomy Center) et al.

Identifying the young objects in star forming regions is the prerequisite for any study of the early phases of stellar evolution. Our goal to derive a census of young stars and brown dwarfs in nearby clusters. This enables us to put constraints on key diagnostics for our understanding of star formation, including the Initial Mass Function, and to study fundamental problems, e.g. the relevance of dynamical interactions and turbulent fragmentation for the formation of stars.

The specific goal of the SONYC survey (short for Substellar Objects in Nearby Young Clusters) is to carry out extremely deep observations to identify objects down to only a few Jupiter masses (0.005 solar masses). We want to study the substellar part of the IMF and find the lowest mass limit for star formation. In this project we use optical and near-infrared wide-field imaging from 8-m telescopes (Subaru, VLT) combined with mid-infrared data from the Spitzer Space Telescope to select candidates. This is followed by low-resolution spectroscopy to look for evidence of youth and thus confirm the nature of the candidates. In the first SONYC publication focused on the cluster NGC1333 we found anomalies in the mass function at substellar masses - a high fraction of brown dwarfs and a cut-off in the mass distribution at 0.015-0.02 solar masses. Currently we are finishing the analysis for the Rho-Oph star forming region, where we identify a new sample of brown dwarf candidates. The analysis for the third region Chamaeleon-I is in progress.

In addition, we have almost finished a survey in the small molecular cloud IC1396W. At a distance of 750 pc, this region is a challenge for current instrumentation. We developed a combined colour-variability criterion to identify young stellar objects, based on a imaging time series obtained with the UKIRT telescope. We found only very few young stars in IC1396W, which points to star forming efficiency much lower than in nearby regions. Serendipitously the survey yielded two new eclipsing binaries.

3.3.8 Characterising Young Stellar Objects and Their Environment

A. Scholz, A Caratti o Garatti, D. Wilner (Center for Astrophysics), R. Jayawardhana (Univ. Toronto), K. Wood (St. Andrews), B. Stelzer (Palermo) et al.

In a number of detailed case studies we aim to provide a close-up view on young stellar objects and their environment. This includes their natal cloud, the envelope, accretion disk, as well as the innermost accretion zone. In addition, we want to provide improved constraints on the fundamental properties of the central sources, to be able to put the objects in an Hertzsprung-Russell diagram. The hope is to use these case studies improve our understanding about the early evolutionary phases of young stars and brown dwarfs.

We have almost finished an extensive study of the protostellar system IRAS04325+2512 in the Taurus-Auriga star forming region. For this multiple system we have obtained images and spectra from Gemini, the Submillimeter Array, and ESO, complemented by data from Spitzer and various archives. All our images have a spatial resolution of 1 arcsecond or better (i.e. less than 150 AU). Based on this rich dataset we derive effective temperatures for the central sources and provide robust constraints for the complex spatial configuration. For this particular case there is some evidence for primordial misalignments in the disk-binary orientation, which favours turbulent fragmentation as a formation scenario.

The object FU Tau A is a brown dwarf recently identified as part of a binary system that has most likely formed in isolation. Based on Chandra observations we have now evidence for strong accretion-induced X-ray emission from this source. This is the most X-ray active brown dwarf ever identified. Using optical spectra and the available archive photometry our goal is to understand the accretion process for this prototypical substellar object. Strong variability in the accretion rate and/or configuration is likely. These results will be published as a Letter in Monthly Notices of the Royal Astronomical Society.

3.3.9 Measure variations in Accretion and Outflow in a Large Sample of Protostars

G.M. Costigan, A. Scholz and J. Vink (Armagh Observatory)

Young stars are observed to accrete gas from a circumstellar disk. This is the final phase of the accretion of matter and angular momentum. The most successful model for this process is magnetospheric accretion, i.e. the funneling of gas along the lines of strong magnetic fields. Until recently disk accretion was mostly studied as a static phenomenon, despite the overwhelming observational evidence for strong variations. In addition, accretion variability has only been studied for small samples of objects.

In a project dubbed LAMP (Long-term Accretion Monitoring Program) we aim to make progress in understanding the dynamics of the accretion process. The core of the program is a multi-epoch time series obtained with FLAMES at the VLT. FLAMES is a fibre spectrograph which we use to observe about 50 young stars in the Chamaeleon I star forming region. Ultimately we hope to obtain about 20 high-resolution spectra for each of these objects, covering timescales from weeks to three years.

As part of her new PhD project, the Lindsay Scholar, G. M. Costigan, has recently started to analyse the first set of FLAMES spectra. She has measured line-widths for accretion-related emission lines and iden-

tified the variable sources in the sample. These measurements will lead to the first reliable assessment of accretion rate changes for a large sample of young stars.

3.3.10 Investigating gas physical conditions and dust reprocessing in jets from young stars

Linda Podio, D. Coffey, E. Whelan and T. Ray

This research activity is focused on studying the physics and the origin of stellar jets through the analysis of spectroscopic observations at optical and near-infrared wavelengths.

Application of spectral diagnostic techniques to velocity resolved spectra (taken with EFOSC2 at the 3.6m ESO telescope, HIRES at the KECK telescope, and ISAAC at the ESO Very Large Telescope) have allowed us to study the jet physical structure as a function of the gas velocity and to investigate the origin of different velocity components in the jets. Interestingly, we found that, in agreement with the predictions from shock models and magneto-centrifugal models proposed to explain jet launching, the high velocity component is denser and more excited (Podio et al. 2009, Podio et al. in preparation, Garcia Lopez et al. 2009).

In parallel, the analysis of high angular resolution observations taken with the Hubble Space Telescope allowed us to trace the morphology, physics, and kinematics of the jet down to 15 AU from the source and across its axis, thus probing the region where the flow is accelerated and collimated. This provides stringent constraints on the mechanism generating the jet. For example, we showed that the high velocity gas in the jet is denser and more excited and is confined to the jet axis, i.e. the collimation angle increases at lower velocities (Bacciotti et al., in preparation).

Moreover, we investigated dust reprocessing in stellar jets, a topic that has been poorly explored to date. This analysis showed that the jet still contains a measurable amount of dust (Podio et al. 2009, Podio et al. in preparation). This finding put severe constraints on the extent of the region from which the jet is launched (Podio et al. 2009).

Finally our spectral diagnostic technique have been applied to analyse faint forbidden lines detected in the spectra of young brown dwarfs. This allowed us to estimate the mass loss rate for these sources. We found that the mass ejection to mass accretion ratio is 0.1, suggesting brown dwarfs are very similar to solar mass Classical T Tauri star outflows (Whelan et al. 2009).

3.3.11 Formation of Structures in HII Regions

J. Mackey and A.J. Lim

J. Mackey has developed a modular Magneto-Hydrodynamics (MHD) code with ray-tracing radiative transfer as part of his PhD thesis supervised by A. Lim. This code has been used to study the evolution of ionised Hydrogen (H II) regions which grow around young massive stars. We have performed high-resolution parallel 3D numerical simulations of the formation of dense pillars of gas (known as elephant trunks) which are observed on the boundaries of large H II regions. Our results demonstrate that a mechanism based on the shadowing of radiation from nearby young stars is a viable explanation for the formation of these pillars. Detailed analysis of our simulation data also provides a possible explanation for unusual velocity measurements obtained from the Eagle Nebula (M16) pillars.

The simulations were run on the ICHEC supercomputing system "Stokes". Early results from this research were presented at the European Week of Astronomy and Space Sciences (incorporating the RAS NAM2009 and EAS JENAM2009 meetings) from 20-23 April 2009, and were the subject of a press release which attracted media interest including an RTE television news piece (23rd April 2009) and a Space.com online article `http://www.space.com/scienceastronomy/090422-nebula-pillars.html`.

We are currently extending our research by investigating the influence of an ambient magnetic field on the types of structures generated by the shadowing mechanism. Initial results indicate the strength and orientation of the field to be an important component of this theory of pillar formation.

3.3.12 Observing Outflows Close to the Ejection Engine

Deirdre Coffey, Linda Podio and T. Ray

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. More statistical evidence is required, such as examining jets at various evolutionary stages, and examining the disks of systems for which the supposed jet rotation has been measured. The Gemini near-infrared spectrograph (GNIRS) on GEMINI South revealed possible rotation signatures in near infrared lines of 4 outflow sources from embedded Class 0 and I stars, giving an indication of the possible evolution of angular momentum extraction over time. (Coffey et al., 2010 submitted). Observations have been conducted with the AO-assisted near-infrared integral field spectrometer (NIFS) on GEMINI North of the disk of the T Tauri star, RY Tau for which the supposed sense of jet rotation is known (P.I. Coffey). Furthermore, time has also been granted on ESO's VLT CRyogenic high-resolution InfraRed Echelle Spectrograph (CRIRES) to study, using spectro-astrometry, the disk of the T Tauri star Th 28 (P.I. Coffey). These 2 cases will increase to 5 the number of targets for which both jet and disk rotation sense have been measured, allowing us to test further whether we are observing jet rotation.

Other work included investigation of the origin of permitted lines which are easily excited in the circumstellar region of young accreting stars. These lines may include contributions from both the accretion columns and the outflowing material, and thus their analysis can shed light on the central engine for the jet launching and its relationship with magnetospheric accretion. Direct observations were reported of the high excitation H I lines of Paschen Beta and Brackett Gamma from the Th 28 T Tauri outflow within the first arcseconds of the jet launching region using the VLT Infrared Spectrometer And Array Camera (ISAAC), thus confirming that hydrogen permitted lines are not only tracers of accretion but also ejection (Coffey et al., submitted).

3.3.13 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 cosmic microwave background (CMB) observations in order to correctly characterise the contaminating foreground emission; for star and planetary formation it is impor-

tant because it potentially probes a regime of grain sizes that is not otherwise easily observable.

Although a number of objects have now been found to exhibit anomalous microwave emission, attributed to spinning dust, it is still unclear what differentiates those objects from the many other seemingly similar targets that do not show the excess.

A. Scaife (AS) is working on the identification and characterization of the anomalous emission attributed to spinning dust. In a recent paper (arXiv0910.4011) she published the first observational evidence for a spatial correlation between the anomalous microwave emission and MIR emission from very small dust grains.

AS is PI of a large joint observing program with the AMI telescope at 12–18 GHz (UK) and the SZA telescope at 30 GHz (USA) to study the microwave spectrum of star formation regions selected from the Spitzer c2d program. This project is in collaboration with colleagues in the UK and the USA.

AS is PI of an observing program with the MUSTANG camera on the GBT to investigate the 90 GHz emission from a previously identified sample of star formation regions which exhibit anomalous microwave emission. This project is in collaboration with colleagues in the UK and the USA.

AS is PI of an observing program with the HARP instrument on the JCMT to investigate the possibility of previously unidentified VeLLoS within star formation regions which exhibit anomalous dust emission. This project is in collaboration with colleagues in the UK.

AS is involved in the Canadian-lead science case for a Q Band instrument on the ALMA telescope (arXiv0910.1609) with respect to studying anomalous dust emission.

3.3.14 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 is co-I of the proposed Cosmic Magnetism KSP for the MeerKAT telescope, the South African SKA pathfinder instrument. This project aims to investigate the magnetic field structure of the inter-galactic filaments in galaxy groups and clusters. This project is in collaboration with colleagues in the UK, Germany, the Netherlands and Australia.

3.3.15 The Sunyaev–Zel'dovich Effect

Anna 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.

AS is leading the SZ side of a joint AMI–XMM project to provide combined analysis of high temperature galaxy clusters.

3.3.16 Starburst Evolution

Anna Scaife

AS is involved in a multi-frequency analysis of the radio spectrum of Ultra Luminous IRAS Galaxies (ULIRGs). AS visited the GMRT (India) to make new observations of the low frequency emission from these objects and is co-I on an observing project with the AMI LA (UK) to make high resolution, high frequency measurements of the same sample of objects. This work will investigate the discrepancy between the thermal fraction indicated by free-free absorption at the low end of the frequency spectrum and a steepening of the spectral index at the higher end. These projects are in collaboration with colleagues in Italy.

3.3.17 Magnetic Fields of Fully-Convective Stars

J. Morin

Spectropolarimetric observations of main sequence M dwarfs have already led to very important results. In particular, previous work has demonstrated that stars just below the full-convection divide are able to trigger strong and long-lived large-scale fields much more efficiently than more massive partly-convective ones. The most recent observations reveal that below 0.2 $M_{\odot}$ stars with very similar masses and rotation rates unexpectedly host radically different magnetic fields.

This first survey will be completed to explore the dynamo response of moderately active fully-convective objects, and to assess the existence of magnetic cycles. The behaviour of late-type objects will be studied through combined spectropolarimetric and radio observations, in order to understand why very similar stars generate such widely different fields. In parallel, new MHD simulations of dynamo action in fully-convective stars will aim to understand the discrepancies between the first observations and theoretical studies. Spectropolarimetric observations of T Tauri stars will be carried out in parallel to highlight similarities and differences between dynamo processes in main sequence and pre-main sequence fully convective stars.

3.3.18 JETSET

T.P. Ray, JETSET Network Coordinator

The final meeting of the JETSET Consortium was held in Dornberg Castle near Jena in Germany in January. Here presentations were made by early stage and experienced network researchers of their work to date. All students were on course to finish their PhD studies and submit their thesis within a few months of the termination of the network. A discussion was held on possible industrial links that the network could develop to strengthen any future application for continued funding under Framework 7's Marie Curie Programme. A final report was presented to the Commission which clearly illustrated the enormous success of JETSET not only in training but also in terms of new scientific collaborations (for example, the network produced a total of approximately 200 joint publications). This report was approved and the outstanding funding (10% of the total budget) distributed to the nodes.

An application for continuation of the network, with ten industrial partners including Springer-Verlag and Astrium EADS and three new full partners including IBM, PALS in Prague and the Max Planck Institute for Astronomy in Heidelberg, was submitted for consideration by the Commission.

3.3.19 MIRI

T. Ray with B. Espey (TCD) and B. Frye (DCU)

The Mid-Infrared Instrument (MIRI) for the James Webb Space Telescope (JWST) is on track for delivery to NASA Goddard in early 2011 following testing of the Flight Model (FM). The FM is currently under construction and will be tested under cryogenic conditions (7K) at the Rutherford Appleton Laboratory (RAL). As the FM DIAS filters and beam-splitters have been delivered, the Irish hardware contribution to MIRI is now complete. NASA have informed the MIRI Consortium that want the consortium to provide much of the software for pipeline calibration and subsequent data analysis. Funding was secured for two software developers (at the DIAS Scientific Officer grade) under the ESA/Prodex programme and two two-year positions were advertised on appropriate mailing lists. Both positions were filled and Julien Morin (formerly from Grenoble) and Anna Scaife (formerly from Cambridge) took up their posts in November and December respectively. It is also worth noting that Enterprise Ireland have indicated their willingness to continue supporting MIRI software development, subject to available funds,from the next tranche of Prodex funding, until launch (2013).

The MIRI software team will eventually be coordinated from the Astronomy Technology Centre (ATC) in Edinburgh and will consist of 6 FTEs (possibly growing to 8 FTEs immediately prior to launch). Fred Lahuis (SRON in the Netherlands) will act as the interim software lead. It is thus envisaged that DIAS will be in a position to make a major contribution to the MIRI software effort in collaboration with the Space Telescope Science Institute in Baltimore.

Work has begun on defining the core (guaranteed time) program using MIRI. T.P. Ray is involved with E. Dishoek (Leiden) and Henrik Beuther (Heidelberg) in the star formation proposal. Preliminary discussions were held with our US colleagues (responsible for supplying the MIRI focal plane detectors) to pool our guaranteed time resources.

It is worth also mentioning that a large allocation (approximately 600 hrs) of extended Multi-Element Radio Linked Interferometer Network (e-MERLIN) time has been granted to survey jets from young stars as part of the e-MERLIN Legacy Programme. e-MERLIN is currently being commissioned and will provide the deepest radio images yet of these outflows.

3.4 GRB and stellar evolution studies

Evert Meurs

3.4.1 Gamma Ray Bursts: REM Telescope observations and afterglow lightcurves

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

Only a couple of Gamma Ray Burst (GRB) afterglows (one of which a first detection) could be detected with the REM Telescope throughout the year, which was a consequence of the observing programme of the Swift satellite.

Further work was carried out on modelling supernova contributions to GRB afterglow lightcurves, which employs the cosmological K-corrections that we have developed for all main types of supernovae.

3.4.2 High resolution echelle spectroscopy of GRB afterglows

E.J.A. Meurs, L. Norci and P. Ward (DCU), F. Fiore, V. DÕElia, S. Piranomonte (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 analysis of our high signal-to-noise, high-resolution spectrum of the GRB afterglow of the 'naked-eye' burst, GRB080319B, was finalised, emphasizing the strongest Fe II fine structure lines ever observed for a GRB. The decrease in optical depth and in optical/UV flux of these lines in a spectrum taken a few hours later demonstrates that the excitation of the fine structure lines is due to UV pumping. The line-of-sight absorbers in the host galaxy are found to be at 2-6 kpc from the GRB site. Several absorbing systems lying between us and GRB080319B, along the line-of-sight to this GRB, could also be studied, featuring absorption lines due to Mg II and other species. The distribution of Mg II line strengths is in agreement with the excess of strong Mg II absorbers for GRBs as compared to quasar lines-of-sight. This difference is not caused by a difference in size of the GRB and quasar emitting regions.

Detailed echelle spectra had also been secured for the burst GRB080330. Assuming again UV pumping, the bluemost absorption component in the host galaxy system appears to be much closer to the burst in this case, at about 0.3 kpc from the GRB site. For this study, as well as the previous one on GRB080319B, a novel time-dependent photo-excitation code was employed. .

3.4.3 Echelle spectroscopy of normal and runaway OB stars

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

Two programmes of optical spectroscopy have been conducted, employing the 1.52 m telescope of Loiano Observatory (Italy). For one programme, aimed at determining rotational velocities of OB runaway stars, a few additional spectra were obtained. The results support the idea that the O type runaways, rather than the B types, acquired their velocities as a result of a supernova event in a binary (mass transfer episode leading to increased rotational velocity). In the other programme we are completing a census of all Northern OB stars with magnitude V<9, to find hitherto unrecognized runaway objects.

3.4.4 OB runaway star lightcurves

E.J.A. Meurs, S. Reynolds (DCU)

High-precision photometric lightcurves of OB runaway stars may allow to recognize collapsed companions (i.e., neutron stars) to these stars. The presence of a (close) collapsed companion would be noticeable from the gravitational distortion of the shape of the normal star (the runaway star as such), which causes small, periodic light variations. Recognizing a collapsed companion is relevant in view of the likely occurrence of a supernova in a binary that led to the observed high space velocities of these stars. The database used for this investigation is provided by the results of photometric measure-

ments that were carried out with the Hipparcos astrometric satellite. A couple of promising cases emerged from this project.

3.4.5 High-energy emission from young stellar clusters

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

We are examining the youngest Galactic stellar clusters at X-rays (using Chandra and XMM-Newton data), to confront models of high-energy emission from such very young clusters with the observational reality, without yet the complications of evolved binaries (i.e., X-ray binaries) or supernova remnants. Our analysis of X-ray data for the very young Galactic Super Star Cluster Westerlund 1 focussed on assessing the role of Pre-Main Sequence stars as potential contributors to the diffuse hard X-ray emission component in this cluster.

3.4.6 AGN contributions to HDF galaxies

E.J.A. Meurs, C. Helly (DCU) For a particular colour versus spectral slope diagram for high redshift galaxies in the Hubble Deep Fields, tracks were calculated that represent varying levels of an active nucleus contribution to the light emission from these objects, for several relevant models of galaxies.

3.5 Dosimetry for Biological Experiments in Space (Dobies)

Denis O'Sullivan

3.5.1 ISS Flight 13S

Much of the DOBIES research completed in 2009 concerned the experiment carried out on the ISS 13S flight of the Space Shuttle in the autumn of 2008 (12th - 24th October) in the Kubic facility in the European Columbus Module. This work is a collaboration with SCK-CEN, Belgium; JSC, Houston; NPI, Prague; OSU, USA; and DIAS. DIAS/JSC are responsible for determining the cosmic ray linear energy transfer (LET) spectra in the exposed detectors. Preliminary results obtained by the DIAS/JSC team for one detector stack were reported at the Prodex meeting in Dublin in April 2009. Work continued throughout the summer and the final results for three detector stacks were presented at the international "Workshop on Radiation Measurements on the International Space Station", WRMISS, held in Dublin in September 2009. Trends observed in the preliminary data were confirmed and the analysis showed higher doses of radiation exposure than those observed in the experiments undertaken in 2006 (see Fig 2). The magnitude of the increase was consistent with the phase of the solar cycle which was closer to the minimum in late 2008 and this allowed a greater flux of galactic cosmic rays to penetrate to near the International Space Station orbit.

3.5.2 Expose-E and Ying B1 and B2

In 2007 DIAS/JSC detector stacks were installed on the Columbus maiden flight in collaboration with DLR and SCK-Centre detectors and were exposed on a platform outside the ISS for about 2 years. These detectors measured the direct radiation intensity in space and obtained very valuable data regarding extra vehicular activities. The detectors were returned in the autumn of 2009 and analysis will begin in 2010. DIAS/JSC detec-

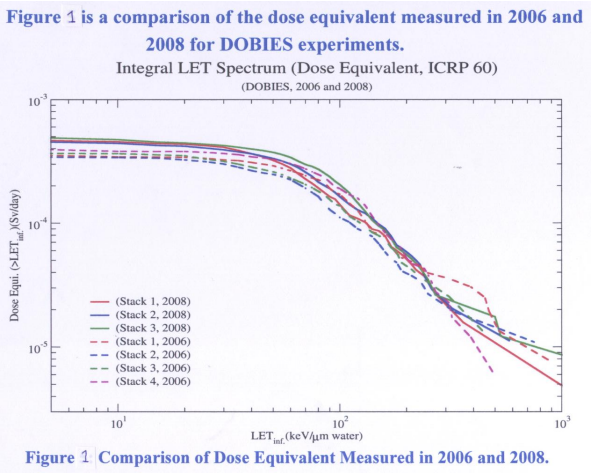

Figure 2:

tors were exposed also on the Japanese missions Ying B1 and B2 between 30.9.2009 and 11.10.2009. Analysis will start shortly.

4 Publications

4.1 Refereed Publications

Note that all the publications listed as Aharonian et al (HESS collaboration) include F. Aharonian, L. Drury and S. Gabici as co-authors from DIAS. Almost all these publications are available online as a private library under the ADS using the following URL:

`http://adsabs.harvard.edu/cgi-bin/nph-abs_connect?library&libname=Ref2009&libid=4794ca7845`

1. Aharonian, F., et al.: Probing the ATIC peak in the cosmic-ray electron spectrum with H.E.S.S. *Astronomy and Astrophysics* (2009) **508** 561-564.
2. Aharonian, F., et al.: Discovery of Very High Energy γ-Ray Emission from Centaurus a with H.E.S.S. *Astrophysical Journal* (2009) **695** L40-L44.
3. Aharonian, F., et al.: Simultaneous Observations of PKS 2155-304 with HESS, Fermi, RXTE, and Atom: Spectral Energy Distributions and Variability in a Low State *Astrophysical Journal* (2009) **696** L150-L155.
4. D'Elia, V., et al.: The Prompt, High-Resolution Spectroscopic View of the "Naked-Eye" GRB080319B *Astrophysical Journal* (2009) **694** 332-338.
5. Hinton, J. A., et al.: HESS J0632+057: A New Gamma-Ray Binary? *Astrophysical Journal* (2009) **690** L101-L104.
6. Rykoff, E. S., et al.: Looking Into the Fireball: ROTSE-III and Swift Observations of Early Gamma-ray Burst Afterglows *Astrophysical Journal* (2009) **702** 489-505.
7. Acciari, V. A., et al.: Radio Imaging of the Very-High-Energy γ-Ray Emission Region in the Central Engine of a Radio Galaxy *Science* (2009) **325** 444
8. O'C. Drury, L., Aharonian, F. A., Malyshev, D., & Gabici, S.: On the plasma temperature in supernova remnants with cosmic-ray modified shocks *Astronomy and Astrophysics* (2009) **496** 1-6.
9. Takahashi, Tadayuki, Kishishita, Tetsuichi, Uchiyama, Yasunobu, Tanaka, Takaaki, Yamaoka, Kazutaka, Khangulyan, Dmitry, Aharonian, Felix A., Bosch-Ramon, Valenti, & Hinton, Jim A.: Study of the Spectral and Temporal Characteristics of X-Ray Emission of the Gamma-Ray Binary LS 5039 with Suzaku *Astrophysical Journal* (2009) **697** 592-600.
10. Aharonian, F., et al.: Discovery of Gamma-Ray Emission From the Shell-Type Supernova Remnant RCW 86 With Hess *Astrophysical Journal* (2009) **692** 1500-1505.
11. Aharonian, F., et al.: A Search for a Dark Matter Annihilation Signal Toward the Canis Major Overdensity with H.E.S.S. *Astrophysical Journal* (2009) **691** 175-181.
12. Aharonian, F., et al.: Spectrum and variability of the Galactic center VHE γ-ray source HESS J1745-290 *Astronomy and Astrophysics* (2009) **503** 817-825.

13. Aharonian, F., et al.: Simultaneous multiwavelength observations of the second exceptional γ-ray flare of PKS 2155-304 in July 2006 *Astronomy and Astrophysics* (2009) **502** 749-770.

14. Aharonian, F., et al.: Constraints on the multi-TeV particle population in the Coma galaxy cluster with HESS observations *Astronomy and Astrophysics* (2009) **502** 437-443.

15. Aharonian, F., et al.: Very high energy gamma-ray observations of the galaxy clusters Abell 496 and Abell 85 with HESS *Astronomy and Astrophysics* (2009) **495** 27-35.

16. Gabici, S., Aharonian, F. A., & Casanova, S.: Broad-band non-thermal emission from molecular clouds illuminated by cosmic rays from nearby supernova remnants *Monthly Notices of the Royal Astronomical Society* (2009) **396** 1629-1639.

17. Taylor, Andrew M. & Aharonian, Felix A.: Spectral shape and photon fraction as signatures of the Greisen-Zatsepin-Kuzmin cutoff *Physical Review D* (2009) **79** 083010

18. Acero, F., et al.: Detection of Gamma Rays from a Starburst Galaxy *Science* (2009) **326** 1080

19. Aharonian, F., et al.: Detection of very high energy radiation from HESS J1908+063 confirms the Milagro unidentified source MGRO J1908+06 *Astronomy and Astrophysics* (2009) **499** 723-728.

20. Vannoni, G., Gabici, S., & Aharonian, F. A.: Diffusive shock acceleration in radiation-dominated environments *Astronomy and Astrophysics* (2009) **497** 17-26.

21. Whelan, E. T., Ray, T. P., & Bacciotti, F.: Uncovering the Outflow Driven by the Brown Dwarf LS-RCrA 1: Hα as a Tracer of Outflow Activity in Brown Dwarfs *Astrophysical Journal* (2009) **691** L106-L110.

22. Aharonian, F., et al.: HESS observations of γ-ray bursts in 2003-2007 *Astronomy and Astrophysics* (2009) **495** 505-512.

23. Kirk, Jason M., et al.: The Spitzer Survey of Interstellar Clouds in the Gould Belt. II. The Cepheus Flare Observed with IRAC and MIPS *Astrophysical Journal Supplement Series* (2009) **185** 198-249.

24. Skilton, J. L., et al.: The radio counterpart of the likely TeV binary HESSJ0632+057 *Monthly Notices of the Royal Astronomical Society* (2009) **399** 317-322.

25. Vergani, S. D., Petitjean, P., Ledoux, C., Vreeswijk, P., Smette, A., & Meurs, E. J. A.: Statistics and characteristics of MgII absorbers along GRB lines of sight observed with VLT-UVES *Astronomy and Astrophysics* (2009) **503** 771-781.

26. Aharonian, F., et al.: HESS upper limit on the very high energy γ-ray emission from the globular cluster 47 Tucanae *Astronomy and Astrophysics* (2009) **499** 273-277.

27. Aharonian, F., et al.: HESS Observations of the Prompt and Afterglow Phases of GRB 060602B *Astrophysical Journal* (2009) **690** 1068-1073.

28. Zapatero Osorio, M. R., Martín, E. L., del Burgo, C., Deshpande, R., Rodler, F., & Montgomery, M. M.: Infrared radial velocities of vB 10 *Astronomy and Astrophysics* (2009) **505** L5-L8.

29. Fukui, Yasuo, et al.: A Peculiar Jet and Arc of Molecular Gas toward the Rich and Young Stellar Cluster Westerlund 2 and a TeV Gamma Ray Source *Publications of the Astronomical Society of Japan* (2009) **61** L23

30. D'Elia, V., et al.: UVES/VLT high resolution absorption spectroscopy of the GRB 080330 afterglow: a study of the GRB host galaxy and intervening absorbers *Astronomy and Astrophysics* (2009) **503** 437-444.

31. Dionatos, O., Nisini, B., Garcia Lopez, R., Giannini, T., Davis, C. J., Smith, M. D., Ray, T. P., & DeLuca, M.: Atomic Jets from Class 0 Sources Detected by Spitzer: The Case of L1448-C *Astrophysical Journal* (2009) **692** 1-11.

32. Vink, Jacco & Bamba, Aya: The Discovery of a Pulsar Wind Nebula Around the Magnetar Candidate AXP 1E1547.0-5408 *Astrophysical Journal* (2009) **707** L148-L152.

33. Aharonian, F., et al.: Very high energy γ-ray observations of the binary PSR B1259-63/SS2883 around the 2007 Periastron *Astronomy and Astrophysics* (2009) **507** 389-396.

34. Rieger, F. M. & Aharonian, F. A.: Centaurus A as TeV γ-ray and possible UHE cosmic-ray source *Astronomy and Astrophysics* (2009) **506** L41-L44.

35. Del Burgo, C., Martín, E. L., Zapatero Osorio, M. R., & Hauschildt, P. H.: Physical parameters of T dwarfs derived from high-resolution near-infrared spectra *Astronomy and Astrophysics* (2009) **501** 1059-1071.

36. Bellan, P. M., Livio, M., Kato, Y., Lebedev, S. V., Ray, T. P., Ferrari, A., Hartigan, P., Frank, A., Foster, J. M., & Nicolaï, P.: Astrophysical jets: Observations, numerical simulations, and laboratory experiments *Physics of Plasmas* (2009) **16** 041005

37. Acero, F., et al.: Localizing the VHE γ-ray source at the Galactic Centre *Monthly Notices of the Royal Astronomical Society* (2009) 1915

38. Podio, L., Medves, S., Bacciotti, F., Eislöffel, J., & Ray, T.: Physical structure and dust reprocessing in a sample of HH jets *Astronomy and Astrophysics* (2009) **506** 779-788.

39. Chernyakova, M., Neronov, A., Aharonian, F., Uchiyama, Y., & Takahashi, T.: X-ray observations of PSR B1259-63 near the 2007 periastron passage *Monthly Notices of the Royal Astronomical Society* (2009) **397** 2123-2132.

40. Suzuki-Vidal, F., et al.: Formation of episodic magnetically driven radiatively cooled plasma jets in the laboratory *Astrophysics and Space Science* (2009) **322** 19-23.

41. Caratti o Garatti, A., Eislöffel, J., Froebrich, D., Nisini, B., Giannini, T., & Calzoletti, L.: First detection of acceleration and deceleration in protostellar jets?. Time variability in the Chamaeleontis II outflows *Astronomy and Astrophysics* (2009) **502** 579-597.

42. O'C Drury, L.: Energetic particles in the universe; how does nature beat CERN? *Plasma Physics and Controlled Fusion* (2009) **51** 124005

43. Maeda, Yoshitomo, et al.: Suzaku X-Ray Imaging and Spectroscopy of Cassiopeia A *Publications of the Astronomical Society of Japan* (2009) **61** 1217

44. Whelan, E. T., Ray, T. P., Podio, L., Bacciotti, F., & Randich, S.: Classical T Tauri-like Outflow Activity in the Brown Dwarf Mass Regime *Astrophysical Journal* (2009) **706** 1054-1068.

45. Hess Collaboration, et al.: HESS upper limits on very high energy gamma-ray emission from the microquasar GRS 1915+105 *Astronomy and Astrophysics* (2009) **508** 1135-1140.

46. Melnikov, S. Yu, Eislöffel, J., Bacciotti, F., Woitas, J., & Ray, T. P.: HST/STIS observations of the RW Aurigae bipolar jet: mapping the physical parameters close to the source *Astronomy and Astrophysics* (2009) **506** 763-777.

47. Downes, T. P. & O'Sullivan, S.: Nonideal Magnetohydrodynamic Turbulent Decay in Molecular Clouds *Astrophysical Journal* (2009) **701** 1258-1268.

48. Mullen, Marie, Brennan, Conor, & Downes, Turlough: A Hybridized Forward Backward Method Applied to Electromagnetic Wave Scattering Problems *IEEE Transactions on Antennas and Propagation* (2009) **57** 1846-1850.

49. Taylor, Andrew M., Gabici, Stefano, White, Richard J., Casanova, Sabrina, & Aharonian, Felix A.: Revisiting the diffuse neutrino flux from the inner Galaxy using new constraints from very high energy γ-ray observations *Nuclear Instruments and Methods in Physics Research A* (2009) **602** 113-116.

50. Downes, Turlough P.: Large-Scale Jet Simulations *Lecture Notes in Physics, Berlin Springer Verlag* (2009) **791** 137

51. Gracia, José, de Colle, Fabio, & Downes, Turlough: Jets From Young Stars V *Lecture Notes in Physics, Berlin Springer Verlag* (2009) **791**

52. Zacharopoulou, Olga, Khangulyan, Dmitry, & Aharonian, Felix: Modification of High Energy γ-RAY Spectrum of Blazars due to Internal and Intergalactic Absorption *International Journal of Modern Physics D* (2009) **18** 1661-1664.

53. Dempsey, Paul & Rieger, Frank M.: On Particle Acceleration in Rotating AGN Flows *International Journal of Modern Physics D* (2009) **18** 1651-1654.

54. Eungwanichayapant, A. & Aharonian, F.: Very High Energy Gamma Rays from $e^{\pm}$ Pair Halos *International Journal of Modern Physics D* (2009) **18** 911-927.

55. G Reitz,Thomas Berger, ... Denis O'Sullivan ... (38 authors): Astronaut's organ dose inferred from measurements using a human phantom outside the International Space Station, *Radiation Research* (2009) **171** 225-235.

4.2 Non-refereed publications

These are available online at:

http://adsabs.harvard.edu/cgi-bin/nph-abs_connect?library&libname=NonRef2009&libid=4794ca7845

1. Brunetti, G., Blasi, P., Cassano, R., & Gabici, S.: High energy emission from galaxy clusters and particle acceleration due to MHD turbulence *American Institute of Physics Conference Series* (2009) **1112** 129-137.
2. Covino, S., et al.: GRB 090102: REM observations of a bright afterglow. *GRB Coordinates Network* (2009) **8763** 1
3. Chernyakova, Maria, Uchiyama, Yasunobu, Takahashi, Tadayuki, Aharonian, Felix, & Neronov, Andrii: X-ray Observations of PSR B1259-63 2007 Periastron Passage *American Institute of Physics Conference Series* (2009) **1126** 271-274.
4. Ray, T. P.: Getting to Grips with the Unknown: How Important are Magnetic Fields in Outflows from Young Stars? *Revista Mexicana de Astronomia y Astrofisica Conference Series* (2009) **36** 179-185.
5. Whelan, Emma M., Ray, Tom, Bacciotti, Francesca, Randich, Sofia, & Natta, Antonella: Searching for Brown Dwarf Outflows *Protostellar Jets in Context* (2009) 259-265.
6. Zapatero Osorio, M. R., Martin, E. L., Del Burgo, C., Deshpande, R., Rodler, F., & Montgomery, M. M.: Infrared radial velocities of vB10 (Zapatero+, 2009) *VizieR Online Data Catalog* (2009) **350** 59005
7. Cabrit, S., et al.: Dynamics of magnetized YSO jets: Examples of results from the JET-SET network *Revista Mexicana de Astronomia y Astrofisica Conference Series* (2009) **36** 171-178.
8. Del Burgo, C., Martin, E. L., Zapatero-Osorio, M. R., & P. Hauschildt.: Infrared spectra of 9 T dwarfs (del Burgo+, 2009) *VizieR Online Data Catalog* (2009) **350** 11059
9. Casanova, S., Aharonian, F. A., Gabici, S., Torii, K., Fukui, Y., Onishi, T., Yamamoto, H., & Kawamura, A.: On the level of the cosmic ray sea flux *American Institute of Physics Conference Series* (2009) **1112** 95-100.
10. Whelan, E. T., Ray, T. P., & Bacciotti, F.: Searching for Optical Outflows Driven by Young Brown Dwarfs with the ESO UV-Visual Echelle Spectrometer UVES *American Institute of Physics Conference Series* (2009) **1094** 39-44.
11. Stecklum, Bringfried, Caratti O Garatti, Alessio, Davis, Chris, Linz, Hendrik, Stanke, Thomas, & Zinnecker, Hans: Verification of Candidate Protostellar Outflows in GLIMPSE *Protostellar Jets in Context* (2009) 619-621.
12. Melnikov, Stanislav, Eislöffel, Jochen, Bacciotti, Francesca, Woitas, Jens, & Ray, Tom: The Physical Properties of the RW Aur Bipolar Jet from HST/STIS High-Resolution Spectra *Protostellar Jets in Context* (2009) 585-587.
13. McGroarty, Fiona, Podio, Linda, Bacciotti, Francesca, & Ray, Tom: Line Diagnostics of Large Scale Jets from Classical T Tauri Stars: The Case of DG Tau *Protostellar Jets in Context* (2009) 577-579.

14. Jones, Aoife C., Shadmehri, Mohsen, & Downes, Turlough P.: Multifluid Simulations of the Kelvin-Helmholtz Instability in a Weakly Ionised Plasma *Protostellar Jets in Context* (2009) 547-549.

15. de Colle, Fabio & Caratti O Garatti, Alessio: Interacting Knots in Jets: Simulations vs. Observations *Protostellar Jets in Context* (2009) 531

16. Colle, Fabio & Caratti O Garatti, Alessio: Interacting Knots in Jets: Simulations vs. Observations *Protostellar Jets in Context* (2009) 531-533.

17. Lopez, Rebecca Garcia, Nisini, Brunella, Giannini, Teresa, Eislöffel, Jochen, Bacciotti, Francesca, & Podio, Linda: Velocity Resolved IR Diagnostics of Class I Jets *Protostellar Jets in Context* (2009) 485

18. Garcia Lopez, Rebecca, Nisini, Brunella, Giannini, Teresa, Eislöffel, Jochen, Bacciotti, Francesca, & Podio, Linda: Velocity Resolved IR Diagnostics of Class I Jets *Protostellar Jets in Context* (2009) 485-490.

19. Downes, Turlough P.: Driving Mechanisms for Molecular Outflows *Protostellar Jets in Context* (2009) 395-404.

20. Caratti O Garatti, Alessio & Eislöffel, Jochen: Jet kinematics *Protostellar Jets in Context* (2009) 329-339.

21. de Colle, Fabio, Del Burgo, Carlos, & Raga, Alejandro C.: Application of Tomographic Techniques to Stellar Jets *Protostellar Jets in Context* (2009) 311

22. Podio, Linda, Medves, Silvia, Bacciotti, Francesca, Eislöffel, Jochen, & Ray, Tom: Position-Velocity Analysis of HH 111: Physical Structure and Dust Content *Protostellar Jets in Context* (2009) 305-310.

23. Caratti O Garatti, Alessio, Eislöffel, Jochen, Froebrich, Dirk, Nisini, Brunella, & Giannini, Teresa: Protostellar Jets Driven by Intermediate- and High-Mass Protostars: An Evolutionary Scenario? *Protostellar Jets in Context* (2009) 267-272.

24. Coffey, Deirdre, Bacciotti, Francesca, Chrysostomou, Antonio, Nisini, Brunetta, & Davis, Chris: Searching for Jet Rotation Signatures in Class 0 and I Jets *Protostellar Jets in Context* (2009) 241-245.

25. Suzuki-Vidal, Francisco, et al.: Formation of Episodic Magnetically Driven Radiatively Cooled Plasma Jets in Laboratory Experiments *Protostellar Jets in Context* (2009) 195-204.

26. Murphy, Gareth C., Zanni, Claudio, & Ferreira, Jonathan: Magnetic Field Advection in Weakly Magnetised Viscous Resistive Accretion Disks: Numerical Simulations *Protostellar Jets in Context* (2009) 117-122.

27. Tsinganos, Kanaris, Ray, Tom, & Stute, Matthias: Protostellar Jets in Context *Protostellar Jets in Context* (2009)

28. Covino, S., et al.: GRB 090509: REM NIR afterglow. *GRB Coordinates Network* (2009) **9327** 1

29. Mohanty, Subhanjoy, et al.: Bridging the Gap Between Stars and Planets: The Formation and Early Evolution of Brown Dwarfs *astro2010: The Astronomy and Astrophysics Decadal Survey* (2009) **2010** 212

4.3 Preprints

As a matter of policy all major publications are posted to ArXiV as publicly available preprints. Those which had not yet appeared in print at the end of 2009 are listed below and are available online at:

`http://adsabs.harvard.edu/cgi-bin/nph-abs_connect?library&libname=Preprints2009&libid=4794ca7845`

1. Casanova, S., Aharonian, F. A., Fukui, Y., Gabici, S., Jones, D. I., Kawamura, A., Onishi, T., Rowell, G., Torii, K., & Yamamoto, H.: Molecular Clouds as Cosmic-Ray Barometers *ArXiv e-prints* (2009) arXiv:0904.2887
2. Chernyakova, M., Neronov, A., & Ribordy, M.: Study of gamma-ray loud binaries in the Fermi era *ArXiv e-prints* (2009) arXiv:0912.3821
3. Garcia Lopez, Rebeca, Nisini, Brunella, Eisloeffel, Jochen, Giannini, Teresa, Bacciotti, Francesca, & Podio, Linda: IR diagnostics of embedded jets: kinematics and physical characteristics of the HH46-47 jet *ArXiv e-prints* (2009) arXiv:0912.2043
4. Mackey, Jonathan & Lim, Andrew J.: Dynamical Models for the Formation of Elephant Trunks in H II Regions *ArXiv e-prints* (2009) arXiv:0912.1499
5. Quirrenbach, A., et al.: CARMENES: Calar Alto high-Resolution search for M dwarfs with Exo-earths with a Near-infrared Echelle Spectrograph *ArXiv e-prints* (2009) arXiv:0912.0561
6. Vannoni, G., Aharonian, F. A., Gabici, S., Kelner, S. R., & Prosekin, A.: Acceleration and radiation of ultra-high energy protons in galaxy clusters *ArXiv e-prints* (2009) arXiv:0910.5715
7. Scaife, Anna M. M., et al.: High resolution AMI Large Array imaging of spinning dust sources: spatially correlated 8 micron emission and evidence of a stellar wind in L675 *ArXiv e-prints* (2009) arXiv:0910.4011
8. Dieckmann, M E, Murphy, G, Meli, A, & Drury, L O C: 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 *ArXiv e-prints* (2009) arXiv:0910.0225
9. Tibbs, Christopher T., et al.: VSA Observations of the Anomalous Microwave Emission in the Perseus Region *ArXiv e-prints* (2009) arXiv:0909.4682
10. Costamante, L., Aharonian, F., Buehler, R., Khangulyan, D., Reimer, A., & Reimer, O.: The new surprising behaviour of the two "prototype" blazars PKS 2155-304 and 3C 279 *ArXiv e-prints* (2009) arXiv:0907.3966

11. Raue, M., et al.: Discovery of VHE gamma-rays from Centaurus A *ArXiv e-prints* (2009) arXiv:0904.2654

4.4 Books and Conference Proceedings

1. Tsinganos, K., Ray, T.P., & Stute, M., (Editors), 2009, Protostellar Jets in Context, Proceedings of the International JETSET Conference organised in Rhodes, Greece, Springer-Verlag

5 Invited talks

- Luke Drury
    1. "A Cross-Scale view of Shock Acceleration", Cross-scale meeting, Cozena, Italy, 9 March.
    2. "How does Nature beat CERN?", European Physical Society Plasma Physics Meeting, Sofia, Bulgaria, 2 July.
    3. "On the plasma temperature in SNRs" Kavli Institute for Theoretical Physics, Santa Barbara, California, 3 September.
    4. "On the plasma temperature in SNRs" UCSD Physics Departmental Seminar, San Diego, California, 24 September.
    5. Three lectures on "The non-thermal Universe" at the Erlangen Astroteilchen Schule, Oberbärenfels, Germany, 8-10 October.
    6. "Recent Progress in Shock Acceleration Theory" HEPRO-II meeting, Buenos Aires, Argentina, 26 October.
- Felix Aharonian
    1. "Probing Cosmic PeVatrons with hard X-rays and low-energy gamma rays", Joint Gamma-ray Mission Meeting 2009, Tokyo, Japan, March 2009
    2. "Exploring Extreme Cosmic Accelerators with gamma-rays, neutrinos and hard X-rays", Leeds University, Leeds, England, March 2009
    3. "Nature's Extreme Particle Accelerators", KIT (Karlsruhe Institute of Technology), Karlsruhe, June 2009
    4. "Discovery of Very High Energy gamma-rays from Centaurus A", talk at the International Workshop "The Many Faces of Centaurus A", Sydney, June 2009
    5. "Gamma-ray/X-ray astrophysics and future directions", invited plenary talk at Australian Astronomical Society Annual Meeting, Melbourne, July 2009
    6. "Gamma Ray Astrophysics", invited plenary talk at the 12th Marcel Grossmann Meeting, Paris, France, July 2009.

7. “Why do you see so many TeV galactic sources?” invited talk at the International workshop “The bright gamma-ray sky”, Frascati, September 2009
8. “Relativistic plasmas in the Universe”, invited plenary talk at the International Conference on “Plasmas in the Laboratory and in the Universe: interactions, patterns, and turbulence”, Como, Italy, Dec 2009

- Tom Ray
  1. “The Mid-Infrared Instrument on JWST”, Enterprise Ireland, 16 April
  2. “Primeval Jets and Outflows”, IAU Joint Discussion 7, Astrophysical Outflows and Associated Accretion Phenomena, Rio de Janeiro, 6-7 August
  3. “Jets on Planetary Scales”, IAU Special Session 7, Young Stellar Objects, Brown Dwarfs and Disks, Rio de Janeiro, 11-13 August
  4. “Outflows from Brown Dwarfs”, Max Camenzind Festschrift, Max Planck Institute for Astronomy, Heidelberg, 26 November
- Stefano Gabici
  1. “Cosmic ray propagation and high energy radiation from molecular clouds”, Workshop: Molecular clouds as probes of cosmic ray acceleration in supernova remnants, Palavas-les-Flots/Carnon, 7-9 September 2009
- Denis O’Sullivan
  1. “Humans in Space”, invited talk at the Physics Department, University of Thessaloniki, Greece, April.

6 Observing Runs: Completed or Awarded in 2009

- A. Caratti o Garatti
  1. **Getting more than a GLIMPSE - Verification of Outflows from massive YSOs**

     June 2009 - 5 nights with SofI at ESO/NTT. PI/CoI: Stecklum B., Caratti o Garatti A., Davis C.J., Linz H., StankeT., Zinnecker H.

     July 2009 - 5 nights with NICS at TNG. PI/CoI: Stecklum B., Caratti o Garatti A., Davis C.J., Linz H., StankeT., Zinnecker H.
  2. **A detailed study of Class I YSOs in CrA**

     June/July 2010 - 19 hrs at ISAAC at ESO/VLT. PI/CoI: Caratti o Garatti A., Garcia Lopez R., Antoniucci S., Peterson D., Bourke T., Barreyre L., Ray T.
- D. Coffey
  1. **Testing the theory of magneto-centrifugal ejection from T Tauri disks**

August 2010-13 hrs using NIFS on Gemini. Program ID: GN-2009B-Q-43. PI/CoI: Chrysostomou, Coffey, Cabrit, Bacciotti, Dougados

2. **Protoplanetary disk rotation probed via spectroastrometry**

   May 2010- 6 hrs using CRIRES on the VLT. Program ID: 385.C-0365(A). PI/CoI: Coffey, Whelan, Podio, Bacciotti, Curran

3. **Investigation Jet Rotation in Young Stars via High Resolution UV Spectra**

   2010- 18 orbits using STIS on HST. Program ID: 11660. PI/CoI: Bacciotti, Coffey, Eislöffel, Ray

- E. J. A. Meurs
  1. Loiano Observatory (Italy), 18-22 March
  2. Loiano Observatory (Italy) , 18-22 November

7 Current Grants

- Luke Drury
  1. PRTLI-4 e-INIS, Project Coordinator
  2. EU Marie Curie fellowship
  3. SFI RFP, one postdoc
- Felix Aharonian
  1. EU FP6 Design Study KM3NeT, 40K, Preparatory Phase 30K
  2. SFI RFP, two postgrads
  3. IRCSET, one postdoc
- Tom Ray
  1. EU JETSET, one postdoc and an administrator, until March 2009
  2. PRODEX MIRI, two scientific officers
  3. SFI RFP, one postdoc and one postgrad
  4. IRCSET, two postdocs
  5. Lindsay Scholarship (DIAS & Armagh Observatory), one postgrad
- Denis O'Sullivan (emeritus)
  1. DOBIES - from Enterprise Ireland under PRODEX, 24k over 2 years

8 Proposals submitted

- PRTLI5 - Submission from DIAS, which included support for CTA and a plan for the redevelopment of Dunsink, was unsuccessful.
- RFP09 - two proposals submitted by new Schrödinger fellows Drs Bamba and Scholz, results not expected until March 2010.
- FP7 - JETset-II proposal submitted but disqualified on technical ground of lack of industrial partners - will resubmit in next round with industry; CORE proposal for e-Infrastructure in support of CTA submitted with DIAS as a partner to call "INFRA-2010-1.2.3: Virtual Research Communities" on Nov 24.

9 Community Service etc

- Luke Drury:
  1. Member of the ICHEC oversight board;
  2. Member of the H.E.S.S. Collaboration Board;
  3. Member of the KM3NeT consortium;
  4. Member of the Council of the RIA
  5. Member of the Grid-Ireland board
- Felix Aharonian:
  1. co-PI of the ROTSE project;
  2. member of the H.E.S.S. Collaboration Board;
  3. member of the Consortium of the KM3NeT;
  4. member of the working group "Science with NeXT" (Japanese next generation X-ray mission);
  5. member ("Principal Scientist/Professor") of the Heidelberg Graduate School of Fundamental Physics at the University of Heidelberg;
  6. Adjunct Professor of the International Center for Relativistic Astrophysics Network, Pescara/Rome
  7. Course of lectures on radiation process in high energy astrophysics, TCD, February
  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, astro-particle 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;
  5. Course of lectures on High Energy Astrophysics, DCU;
  6. Member of the Joint Management Committee, Armagh Observatory and Planetarium (until February).
- 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
  9. Elected to membership of the Royal Irish Academy
  10. National representative at the International Astronomical Union General Assembly, Rio de Janeiro
- Masha Chernyakova
  1. Member of the XMM-Newton AO-9 proposal review panel.

10 Public Outreach

10.1 Statutory Public Lecture

Professor Simon White, Director of the Max-Planck-Institut for Astrophysics in Garching, gave the School's statutory public lecture in UCD on 12 October. His well-attended talk was entitled "All from Nothing: the structuring of our Universe". He provided the following abstract for his talk which was chaired by Prof Peter Duffy of UCD, a former scholar and current research associate of the School.

Telescopes are time-machines. They allow us to see into the distant past. Our deepest images show the Universe not as it is today, but as it was just 400,000 years after the Big Bang. At that time there were no galaxies, no stars, no planets, no people, no familiar elements other than hydrogen and helium. The cosmos contained nothing but weak sound waves in a near-uniform fog. Supercomputers can compress thirteen billion years of cosmic evolution into a few months of calculation to show how these sound waves developed into the rich structure we see around us today. A study of their harmonic content gives clues to their origin. They appear to be an echo of quantum zero-point fluctuations occurring a tiny fraction of a second after the Big Bang. Thus our entire world may be a consequence of the nature of this early vacuum. In a very real sense, everything may have come from nothing.

He was interviewed by Dick Ahlstrom of the Irish Times in advance of his visit, `http://www.irishtimes.com/newspaper/sciencetoday/2009/1001/1224255600204.html`.

10.2 IYA2009

A number of events to mark the International Year of Astronomy were organised jointly with other institutions involved in the public promotion of astronomy.

E.J.A. Meurs gave assistance at the ESO stand at the Young Scientists Exhibition (RDS, Dublin), 9 and 10 January.

In collaboration with Blackrock Castle Observatory in Cork Brother Guy Consolmagno SJ, curator of meteorites in the Vatican Observatory and a well-known author of popular astronomy books, was invited to Ireland. He visited from 19 to 28 March and gave talks in Gonzaga college, Dunsink Observatory, the Cosmos star party in Tullamore and in Blackrock Castle Observatory. His visit attracted considerable media interest, especially when he was photographed with Rory Gallagher's guitar during his visit to Cork.

In collaboration with Armagh Observatory and Blackrock Castle Observatory Caroline Porco, PI of the Cassini mission, was invited to Ireland and gave talks on "Tripping the light fantastic at Saturn" in Dunsink on June 30th, in Cork on July 3rd and in Armagh on July 8th. This visit also attracted considerably media interest with good coverage in both print and radio, for example `http://www.irishtimes.com/newspaper/sciencetoday/2009/0625/1224249487277.html`

In collaboration with Deirdre Kelleghan of the IFAS, Blackrock Castle Observatory, and the

Birr castle science centre a touring exhibition of astronomical art was presented in various venues around the country.

D. Coffey gave a public outreach talk entitled “Exploring the Cosmos: the view from Hubble and Beyond” at the Hill of Tara Visitors’ Centre in July 2009 as part of the annual Tara Lecture Series, and to celebrate the International Year of Astronomy 2009.

T. Ray gave a number of public talks including ones to Galway Astronomical Society (February), Dunsink Observatory (February, October and November), Irish Astronomical Association, Belfast (September)

E.J.A. Meurs assisted with the organization of the digital astronomical photography competition ÔEYE on the SKYÕ, organized by the School of Physical Sciences of DCU. He also was member of the jury for this competition.

10.3 Science Week

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 2009.

Date	School	Principal Speaker
9 Nov	Roselawn National School	S Delaney
	Loretto Secondary School Bray	J Flannery
10 Nov	Blanchardstown NS	D Kelleghen
	St MacDara’s school, Templeogue	D Kelleghen
11 Nov	Scoil Oilibhear, Blanchardstown	D Malyshev
	Loretto Whitehall	P Dempsey
12 Nov	Educate together	D Malyshev
	St Paul’s Walkinstown	T Ray

10.4 Dunsink events

The normal programme of Open Nights concluded in March and recommenced in October. In a welcome development it was supplemented by a growing number of special events for specific interest groups (see Table 1). In addition the Irish Astronomical Society were facilitated by being allowed the use of Dunsink for their meetings (including some evenings devoted to practical instruction). A significant number of events related to the International Year of Astronomy were also held in Dunsink.

Table 1: Dunsink events in 2009

Date	Event	Principal Speaker
7 Jan	Open night	Paul Dempsey
19 Jan	Joint IAS and open night	Denis O'Sullivan
21 Jan	Parent and child event	Emma Whelan
23 Jan	Russian evening	Masha Chernyakova
4 Feb	Open night	Tom Ray
16 Feb	IYA2009	Mike Redfern
18 Feb	Open night	Brian Espey
1 Mar	IFAS workshop	Paul Dempsey
4 Mar	Mature UCD students' evening	J Quinn
9 Mar	Russian educate together group	M Chernyakova
	IAS meeting	J Flannery
11 Mar	Education officers meeting	C Raftery
27 Mar	IYA2009 event	Br G Consolmagno
1 Apr	Hope foundation evening	D Kelleghen
2 Apr	Open night	M McConnell
8 Apr	WITS book launch	D Donnelly
24 Apr	Irish Guides event	D Kelleghen
27 Apr	IAS meeting	
6 May	Hope foundation	
7 May	extra open night	D Gabuzda
9 May	National Art Day	D Kelleghen
11 May	IAS meeting	S Roche
20 Jun	Solar Fest	
30 Jun	IYA2009 talk	C Porco
15 Sep	Invited IYA2009 event	C Odmann
7 Oct	Open night	T Ray
19 Oct	Joint IAS/DIAS event	B O'Halloran
21 Oct	Open night	D Malone (NUIM)
27 Oct	International Young People's evening	M Chernyakova
31 Oct	International Young People's evening	D Malyshev
14-15Nov	Astronomy weekend	multiple
16 Nov	IAS meeting	D Malyshev
17 Nov	Art exhibition event	
18 Nov	Open night	P Rammos
24 Nov	Mount Merrion Art club	D Malyshev
25 Nov	Castleknock Art club	D Malyshev
3 Dec	Open night	M Shadmehri
15 Dec	Google social group	P Rammos
16 Dec	Open night	P Callanan (UCC)

11 Conferences Organised

11.1 Workshop on Radiation Measurements on the International Space Station

Denis O'Sullivan

The 14th Workshop on Radiation Measurements on the International Space Station (WRMISS) was held in Dublin Castle on 8-10 Sept and was opened by Professor Dervilla Donnelly, chairperson of the Council of DIAS. D. O'Sullivan was the local scientific organiser. The Dublin Castle conference centre was provided free of charge by the Irish Government. Previous workshops in the series were held in Oxford, Paris, Berkeley and several other universities and research centres. Preparations for the meeting were the responsibility of Eileen Flood and Anne Grace of DIAS who also took care of all the administration during the workshop. The main funding was supplied by DIAS and the ESA Prodex Office helped also. The meeting was run without a delegate registration fee, as is customary. There were 56 attendees and the distribution, by country, was as follows, USA (14), Germany (9), Hungary (5), Canada (4), Japan (4), Ireland (1), Austria (3), Russia (3), Belgium (2), Czech Republic (2), Greece (2), Sweden (2), Bulgaria (1), Italy (1), Poland (1), The Netherlands (1) United Kingdom (1). In all, 42 papers were read covering a wide range of topics related to experiments already carried out on the ISS, some in progress and others at the planning stage. D O'Sullivan presented the latest DOBIES results. A Workshop dinner was held at the Merrion Hotel on Sept 9th. Fig 3 shows some of the delegates at the Workshop venue.

Figure 3: Group photograph in Dublin castle