# 2005 Annual Report
# School of Cosmic Physics: Astronomy and Astrophysics Section
L. Drury, E. Meurs & T.P. Ray

## 1. General

In 2005 the process of merging the previously separate Astronomy and Astrophysics sections began in earnest although lack of good quality office space prevented all of the staff from Dunsink Observatory being moved to Merrion Square. It is hoped this problem will be overcome in 2006 with the availability of new premises. The EU funded JETSET project, led by the section, began in February. The project is for four years and employs twenty postdoctoral fellows and PhD students (three at DIAS) throughout Europe. The Professorship in Astronomy was advertised widely and attracted an excellent field. Interviews for the position were held in November and Dr. Felix Aharion, of the Max Planck Institute for Nuclear Physics in Heidelberg, accepted the offer of the post. It is hoped that Dr. Aharion will commence working in the section in the autumn of 2006.

## 2. Astronomy and Astrophysics Activities

### IAU Symposium 230

Activities in Dunsink Observatory were dominated throughout the first half of the year by the preparations for IAU Symposium No 230, then the symposium itself in the 3rd week of August (held in Dublin Castle with the kind support of the Minister for Education and Science), and subsequently by the editing of the proceedings. The symposium, on *Populations of high energy sources in galaxies* was regarded by the participants as highly successful and the proceedings are expected to become a valuable reference work. The renowned astrophysicist, Prof. Geoffrey Burbidge, gave a well-attended public talk on the Tuesday evening of the week of the symposium, organized by the symposium's Local Organizing Committee in collaboration with the RIA and the Irish Times.

### Gamma-Ray Bursts and the REM telescope

Work on Gamma Ray Bursts, the most energetic explosive events in the Universe, has now become a well-established research activity within the School. Students have regularly supervised the operation of the automatic REM telescope in La Silla, working from Dunsink Observatory as well as from their homes (since night alerts have to be monitored as soon as possible). Gamma Ray Burst alerts come currently mostly from the dedicated `Swift' high-energy satellite. Besides Gamma Ray Burst follow-up observations, the REM telescope carries out regular monitoring observations, for instance of specific types of galaxies with active nuclei in their centres.

Gamma Ray Bursts, for which a so-called afterglow is detected, lasting for days to months after the burst itself, are in some cases so bright that high-resolution (`echelle'-) spectroscopy can be performed. This provides us with the means to probe the circumburst environment in great detail, showing generally a clumped gas distribution with various velocities relative to the burst itself. This provides highly interesting diagnostics for the possible progenitor stars that exploded in a Gamma Ray

Burst. New data for another couple of bright Afterglows have been secured during the year.

**Neutron Star Studies**

In a feasibility study regarding the upcoming astrometric `Gaia' satellite, it was shown that for roughly one-tenth of the known X-ray binaries (stellar systems consisting of a normal and collapsed companion, a so-called neutron star), one could infer the presence of a compact companion from the orbital wobble observed for the normal star in the system (due to the two stars being in orbit around each other). This will open the way to accurate mass determinations for the neutron stars in these binaries, as well as precise orbital parameters for the systems as such. This work emerged naturally from a project on the production mechanisms for `runaway' stars, massive stars that have acquired a substantial velocity within our Galaxy. One such method concerns the Supernova explosions in which neutron stars are born to impart substantial velocities to the system. In a general approach, dynamical simulations of small stellar groups were carried out with advanced computer codes, together with consideration of the evolutionary development of the stars involved.

A particularly interesting star, with characteristic periods of X-ray emission, has been studied with optical spectroscopy. Some emission lines in its spectrum, and the pattern of variation of these lines, suggest that the X-ray emission is due to an associated compact companion (neutron star) around which material ejected from the optically visible star settles as a so-called accretion disk. The inner parts of these disks become very hot and can emit X-rays. Further spectroscopic data on this object have been collected during the year, leading amongst other things to reconsidering a proposed classification of this star as a particular sub-type of Be stars (stars of spectral type B that exhibit emission lines in their spectra).

**Magnetic Fields in Star Forming Regions**
***R. Curran and T.P. Ray***

Molecular clouds are observed to persist for much longer than their free-fall timescales, suggesting they have some form of support preventing them from collapse (at least initially). Thermal pressure is too weak in comparison to the gravitational stresses in the cloud, and current theory predicts that the support may come from the magnetic field that permeates the gas, and/or the pressure of turbulent eddies - indeed it is likely that these two mechanisms are coupled. We have used a combination of observations and modelling to assess the contributions of the magnetic field and turbulence to the support of clouds.

One of the most direct methods of detecting a magnetic field is to observe the polarised thermal emission from cold dust grains that have been aligned by the field, thus mapping its morphology in the plane of the sky. This method has been used to study the magnetic field of star forming regions like DR21(OH) in detail, using our polarimetry data from the James Clark Maxwell Telescope in conjunction with, Zeeman measurements of the (line-of-sight) magnetic field strength and intermediate resolution polarisation maps observed with the Berkeley-Illinois-Maryland-Association (BIMA) interferometer array. This has enabled a 3-dimensional impression of the magnetic field throughout the cloud to be gained. The magnetic field is found to lie predominantly in the plane-of-the-sky, in an East-West direction (perpendicular to the major-axis of the star-forming region, which has a North-South morphology). The field also remains remarkably uniform throughout the cloud. These two factors may hint at an initially strong field and collapse via ambipolar diffusion. However, analysis of the critical mass-to-flux ratio for this morphology of cloud/magnetic field indicates that the magnetic field is unable to prevent collapse.

**Molecular Cores**

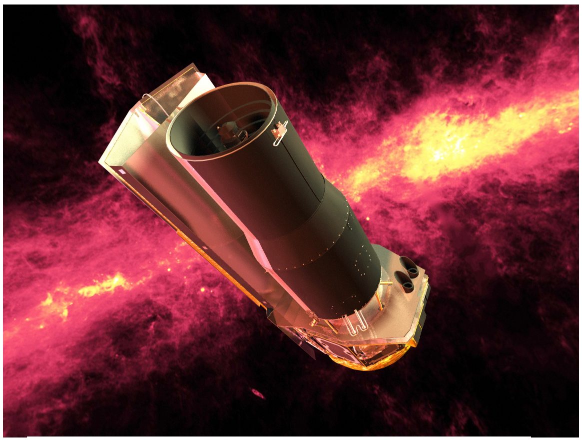
***R. Curran and T.P. Ray***

Modelling of over twenty cores has been carried out using both Bonner-Ebert (BE) hydrostatic sphere and Penston-Larson infall models. This was done by fitting their azimuthally averaged radial density profiles. Current wisdom states that caution should be used when fitting hydrostatic models, as even dynamically evolving cores can appear in "hydrostatic disguise" and fit BE models well. Nevertheless, the central densities, scale radii and core radii (the extent of the fit) can be used as a common metric for both modellers and observers to characterise the cores. Analysis of the line-of-sight velocity dispersions calculated from the fit indicates in most cases larger velocity dispersions than are usually measured in typical high-mass star forming regions. Observations to measure the velocity dispersions in a sub-sample of these cores were recently carried out.

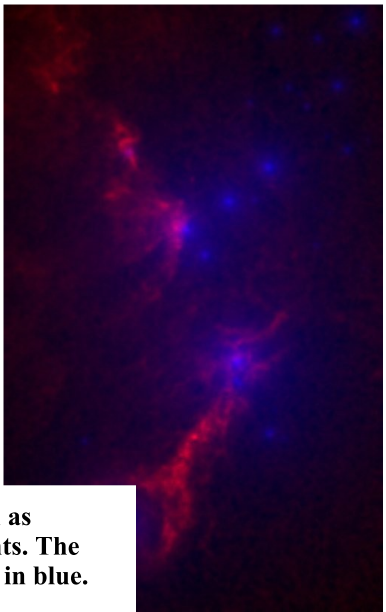
**Spitzer Observations of Weak-line T Tauri Stars**

***À. Gras-Velázquez and T.P. Ray***

Data has been acquired from the Cores to Disk (c2d) Legacy Program, carried out by the Spitzer Space Telescope, to search for disks around weak-line T Tauri stars (WTTS). These stars are thought to be analogues of the young Sun during the first few million years of its life. The emphasis has been on reducing Multi-band Imaging Photometer for Spitzer (MIPS) data at 24 and 70 microns. Combining these new data with optical and near-infrared observations, spectral energy distributions of the WTTS have been constructed to look for infrared excess emission, tell-tail signatures of disks. Evidence has been found for circumstellar disks in 20% of the stars (of a total sample of 30). Interestingly WTTS selected by their X-ray emission do not posses disks while those chosen on the basis of their optical emission do. Thus X-ray selected WTTS are essentially devoid of circumstellar matter in contrast to their optically selected counterparts. This is contrary to the commonly held belief that *all* WTTS do not possess disks.



**Spitzer Space Telescope**



**Extinction (red) in Orion as measured from star counts. The stars of Orion are shown in blue.**

**Measuring Interstellar Extinction from Star Counts**

***D. Froebrich, T.P. Ray, G.C. Murphy, and A. Scholz (University of Toronto)***

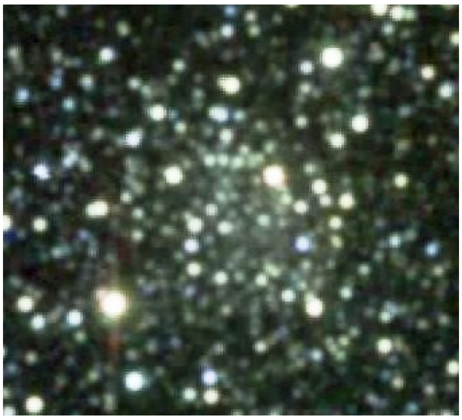
A study has been made of the distribution of gas and dust in several star-forming regions by means of near-infrared (NIR) extinction maps. One important property of dust is how extinction depends on wavelength. Knowing the so-called reddening law allows us to use stellar colours to determine extinction and to measure the mass of gas and dust in a cloud. We have developed methods to determine the extinction law based on star counts and colour excess maps. Those methods have been applied to clouds in Cepheus and Ophiuchus. A dependence of the extinction law on the column density of gas and dust was found. This is of significance for radial density profile analysis of dark clouds.

**The Youngest Stars**
***D. Froebrich***

During the earliest stage of star formation (Class 0) protostars gain most of their final mass. We have investigated how well current models are able to predict the observational properties of these objects. Numerically derived mass accretion rates from gravo-turbulent simulations were combined with an evolutionary model of the envelope structure to obtain model evolutionary tracks for the three main observables (envelope mass, bolometric temperature and luminosity). A three dimensional Kolmogorov-Smirnov test was then applied to quantify the agreement between model predictions and observation. Monte-Carlo methods were used to constrain free model parameters. In general rather poor agreement (70%) of models and observations was found. However, we can conclude from our investigations that star formation is in essence a localised and stochastic process, governed in the majority of regions by turbulence rather than by ambipolar diffusion and that the Class 0 phase lasts between 20 and 60 thousand years.

**Finding Hidden Clusters**
***D. Froebrich***

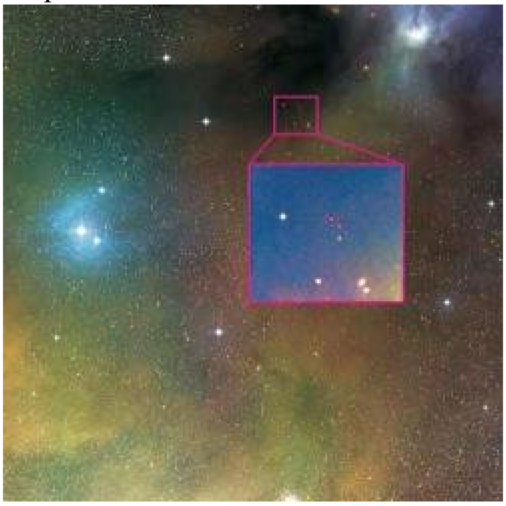
Most stars form in clusters, embedded in clouds of gas and dust. We have used star counts based on the 2 Micron All Sky Survey (2MASS) point source catalogue to obtain a complete sample of all star clusters in the Galactic Plane with |b<20°|. In total1788 cluster candidates were identified of which 86 galactic and 610 open clusters were already known. Thus we have found some1092 new cluster candidates. For all objects radial star density profiles were fitted to obtain the size, stellar density and number of stars in the cluster. Those properties were then used to obtain a measure to classify the new candidates in our sample. It was found that about half of our new candidates are indeed new open clusters. Furthermore we found that star clusters are themselves clustered on scales of about 0.7°. This corresponds to an increased probability of finding cluster pairs on spatial scales of 10-25pc, about the size of typical molecular clouds in the Galaxy.



**A newly discovered Milky Way cluster**

**Searching for Outflows from Brown Dwarfs**
***E. Whelan, T.P. Ray, F. Bacciotti (Arcetri), S. Randich (Arcetri), R. Jayawardhana (University of Toronto)***

Brown dwarfs (BDs) are often referred to as “failed stars” because their mass is insufficient to ignite hydrogen in their cores: They these objects never join the Main Sequence. At the same time evidence has been growing that these objects accrete while young just like ordinary protostars. Moreover it was noticed that in some cases BD spectra contain weak forbidden lines e.g. the [OI] doublet, lines that are traditional tracers of outflow activity. Theoretically however we expected any jet or outflow from a BD to be small in angular size and to be very faint. For these reasons, we applied the novel technique of spectro-astrometry to the emission lines to search for an outflow. Our target was ρ-Oph 102, a young (few million years old) BD of about 60 Jupiter masses deeply embedded in a star formation region. Using data from the Very Large Telescope (VLT) in Chile, we were able to demonstrate that this BD was in fact driving a jet like those seen from T Tauri stars albeit on a much smaller scale. This was the first confirmation that BDs could drive outflows and resulted in a Nature paper published in June 2005. A collaborative project to look at other BD outflow candidates has commenced with Ray Jayawardhana at the University of Toronto. Proposals to observe more BDs with the VLT were successful and the observations are scheduled to be carried out in 2006.



**Discovery of the first jet from a brown dwarf ρ Oph 102 (circled)**

**Integral Field Spectroscopy of T Tauri Star Outflows**
***E. Whelan and T.P. Ray***

Observations of a number of outflows from classical T Tauri stars (e.g. DG Tau and RW Aur)were obtained with the the integral fieldspectrometer OASIS on the William Herschel Telescope on La Palma. The observations were obtained under good seeing and utilizing the adaptive optic system, so they are of very high spatial resolution. The data will primarily be used to provide proper motion information, i.e. to see how the system evolve with time for comparison with models.

**Modelling Infall and Outflow in Young Stars**
***T. Lery and C. Combet***

Work is continuing on developing semi-analytical models that treat both infall and outflows in a coherent fashion According to these models, we consider molecular outflows to be infalling gas that has been deflected outward by the combination of pressure gradients and magnetic fields when approaching the central protostar. We have modified the original self-similar models in order to study the influence of magnetic field and opacity on the solutions. We found that outflows can exist without the presence of a magnetic field, and that infall and outflow rates increase when dust does not dominate the cooling. A complementary line of research is currently ongoing to numerically study the stability of these solutions. This work is still in progress and is performed by implementing a solution of the model into the FLASH numerical code. The latter cannot only handle magneto-hydrodynamic simulations in 3 dimensions but is fully parallelised and uses Adaptive Mesh Refinement (AMR).

**Interacting Jets from Binary Stars and Jet Propagation**

*G.C. Murphy and T. Lery*

Most solar-like stars form in binary systems. There may thus be a period, in the life of a young system, when two or more jets are ejected simultaneously (e.g. as seen in the system L1551-IRS 5). Simulations of what happens when such jets interact have been performed. It is found that for plausible parameters, the interaction can have strong effects on the flow. The effects of binary rotation, and conditions under which the jets could merge, have been examined.

A study of jets propagating under free expansion or in an ambient medium of steeply declining density was carried out The purpose of this was to explain the highly collimated shape of astrophysical jets, which may be caused in part or wholly by the density profile of the ambient medium. In previous studies the ambient cloud into which a jet propagates has been treated as a constant density and pressure structure, whereas in reality it may have a density gradient or cavity. The cavity may be caused by the joint effects of gravitational infall and centrifugal force or by previous episodes of strong ejection from the source.

**Non-Ideal MHD Waves and Structure Formation in the ISM**
*A. Lim, S. Falle (Leeds) and T. Hartquist (Leeds)*

Absorption observations indicate that significant fluctuations in physical conditions in interstellar clouds exist on scales comparable to, or even smaller than, the dissipation length associated with ion-neutral friction. One proposed mechanism whereby such structure can arise is the non-linear coupling of the fast and slow MHD wave modes in a magnetically dominated region. In this model a fast-mode wave can create dense clumps in regions where the velocity gradient in the wave is negative, these clumps are typically bounded by slow-mode shocks and the amount of energy in the slow mode grows linearly with time.

Simulations have been performed of non-ideal hydromagnetic wave evolution in which ion-neutral friction plays a major role. These simulations focus primarily on cases for which the background thermal pressure is very small compared to the background magnetic pressure. For initial disturbances with wavelengths sufficiently large compared to the dissipation length the generation of high-density contrast structures is due to slow-mode wave generation following non-linear steepening of the fast-mode wave. At such wavelengths, the collisions of structures generated in this fashion leads to additional density enhancement for some ranges of the initial wave amplitude. For initial disturbances with sufficiently short wavelengths, ion-neutral damping results in the presence of slow-mode waves; for some ranges of parameters, the dissipation causes higher density contrasts than those found in the corresponding longer wavelength cases.

Large density contrasts on scales comparable to the dissipation length are found only in cases in which the wavelength of the initial perturbation is not too large. This result indicates that the observed small-scale structures may arise by the direct driving of rather short wavelength perturbations. The fact that the short wavelength waves do not propagate far before they are dissipated suggests that the decadal variations in absorption features may be due to phenomena at the surface of clouds where shear boundary layers are sources of high frequency waves.

**MHD Simulations of Star-forming Regions**
*A. Lim, S. Falle (Leeds) and T. Hartquist (Leeds)*

Star-forming regions of the ISM are typically observed to have a low plasma parameter, β, and many studies of structure formation in such regions (including that above) have assumed magnetically dominated initial conditions. They have not, however, addressed the question of how such low β regions can arise. This work consists of the study of a highly idealised situation in which a spherical cloud of gas with moderate β is compressed by a higher external pressure. Fast magneto-hydrodynamic shocks are driven into the cloud and the near the cloud "equator" (with respect to the ambient magnetic field direction) these have the effect of compressing the magnetic field lines and raising the magnetic pressure. Radiative cooling behind these shocks then lowers the gas pressure leading to a region of low β. The simulations show that, for an initial cloud beta of around unity, the cloud interior could can achieve a β~0.03, which is a similar value to that observed in star-forming regions. In addition, the low β region is seen to be in a thermally unstable state which is more conducive to the formation of dense clumps.

The magnetically dominated region is transient in nature since the cloud must eventually equilibrate its pressure with it's surroundings, however for a region the size of a Giant Molecular Cloud (GMC) the lifetime of the low β region does not conflict with the estimates of a few million years for the ages of the stars seen in observed GMCs.

**Equilibrium and Time-Dependent $H_2$ Emission**
***A. Lim, J. Rawlings (UCL), D. A. Williams (UCL) and Stefano Tine (UCL).***

A detailed model of the $H_2$ molecule has been constructed leading to a time dependent cooling function that accounts for the effect of the CMB at high redshift. This involves solving simultaneous differential equations for collisional (de-) excitation and spontaneous/stimulated emission for all 212 ro-vibrational levels considered in the model. A paper giving steady state cooling function at various fixed redshifts is currently being prepared. The steady state cooling rates are obtained by iterating the above system to equilibrium over the relevant parameter space and fits to these data compare well with currently available $H_2$ cooling functions.

This model has been applied to the emission from $H_2$ formed in the chains of aligned knots that define the beams of Herbig-Haro jets. These are sometimes observed both in atomic/ionic as well as in molecular $H_2$ emission lines. Such objects are modelled as jets with an ejection velocity time-variability, which produces internal working surfaces that travel down the jet beam. In a series of axisymmetric gas dynamic and chemical numerical simulations it was found that, for variations with an amplitude of ~ 0.1, the internal working surfaces have appropriate conditions for $H_2$ to be formed (via negative and positive ion gas phase chemistry) and $H_2$ fractions as high as ~ 1-10% can be obtained.

This study suggests that the $H_2$ emission observed in the chains of knots along some HH jets could correspond to molecules formed in situ within the internal working surfaces that travel down the jet flow. Future work will involve the use of the cooling function in a time-dependent manner to study the level populations and emission from molecular gas in dynamical situations where equilibrium populations cannot be assumed both in the current epoch and at high redshift.

**Adaptive Multi-fluid MHD Simulations of Stellar Jets Including Chemical Networks**
***A. Lim and S. Cabrit (Observatoire Paris, DEMIRM)***

Jets from young stellar objects are widely acknowledged to be useful diagnostics of the star formation process and extensive numerical investigation of these phenomena has taken place over the last decade. Previous simulations have usually made the assumption of pure gas dynamics or ideal MHD, however there is significant observational evidence that non-ideal effects may play an important role in the behaviour of stellar jets; for example, observations of high velocity $H_2$ emission have led some researchers to look to so-called "C-shocks" in which the ion-neutral coupling softens the shock discontinuity and may allow molecular gas to survive into the post-shock region.

With this motivation, an adaptive non-ideal MHD code is being developed which is able to follow the chemical evolution of the gas and does not make the assumption that the inertia of the ionic component is negligible. This code will first be applied to jets, for which a large volume of previous work exists and the initial results can be placed in context. In the future, this code will be applied to regions close to the protostellar object in which some models have suggested that ambipolar diffusion is important in the jet launching process.

**Adaptive 3D Calculations of Gravitational Instability in Proto-planetary Disks**
***A. Lim and M. Picket (Purdue University, Calumet)***

Studies of the formation of gas giant planets in self-gravitating disks has been motivated by the recent explosion in the detection of extra-solar planets. One mechanism by which this process can take place is that of gravitational instability, in which a disk with the right physical conditions is unstable to the formation of dense self-gravitating condensations.

This project applies adaptive mesh refinement methods to simulations of protostellar disks in order to resolve more clearly the formation of the condensations (which has been a weakness in previous studies) and address the current uncertainty as to whether gravitational instability can explain the current observed preponderance of extra solar gas-giant planets.

The geometry of this problem has led to the development of a cylindrical adaptive mesh upon which the simulations will be performed. Comparisons with the Cartesian mesh will allow any effects due to grid geometry to be identified and, if necessary, techniques to minimise such effects to be developed.

**2D/3D Studies of MHD Waves in Isothermal and Thermally Unstable Media**
***A. Lim, S.Falle (Leeds) and T. Hartquist (Leeds)***

This involves simulations of both isothermal media, in which the mode-coupling is the primary mechanism for the formation of density structure, and thermally unstable media, in which the mode-coupling can serve as a catalyst for cooling-driven condensation.

Initial results suggest that higher-dimensional effects (such as wave interference or focussing) make the formation of density structure significantly more likely than in the one-dimensional case for given parameters.

**2D/3D Studies of Dense Clumps Interacting with MHD Winds and Shocks**
***A. Lim, S.Falle (Leeds) and T. Hartquist (Leeds)***

Some of the work described above consists of highly idealised simulations in which a clump is assumed a priori to be exposed to an environment of much higher pressure. A more realistic situation is that in which the clump is exposed to a bulk flow in its environment. Future work in this area includes simulations of clumps exposed to MHD shocks and winds to determine under what conditions a magnetically dominated region can be generated and the conditions in, and lifetime of, such a region.

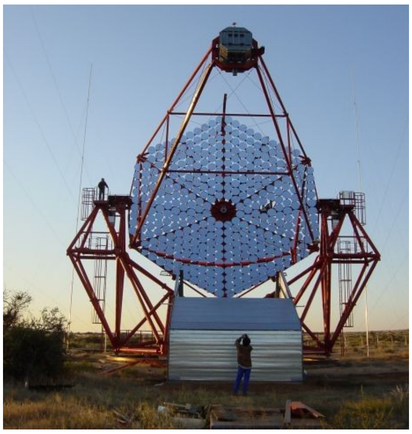
**The Extinction Power Law in Different Interstellar Environments**
***C. del Burgo and D. Froebrich***

A study has been performed of the near-infrared extinction power-law (assumed extinction ( $A_\lambda \quad \lambda^{\beta}$ ) and analysed its spatial variations for different interstellar environments. These methods have been applied to study the properties of dust in the molecular cloud complex LDN 134, where variations in the dust grain size distribution have been found.

**The Properties of Dust in the Interstellar Medium**
***C. del Burgo D. Froebrich, L. Cambrésy (Strasbourg Observatory) and R. Laureijs (ESTEC)***

Far-infrared observations from 60 to 200 μm of a region enclosing the Taurus Molecular Cloud TMC-2, with optical extinction $A_V$ ranging between 0.5 (translucent) to 11 magnitudes (dense) were made. The far-infrared emission was separated into *warm* and *cold* components using ISOPHOT and IRAS data. This separation is based on the very different morphologies of the 60 μm and 200 μm emission maps. The 60 μm emission is used as spatial template of the warm component, and the 200 μm emission ($I_\nu(200)$) as a template for the cold component. The warm component presents an average colour temperature of approximately 20K. The cold component is nearly uniform with a mean temperature of 12.5K in the observed area. The optical depths at 200 μm ($\tau\{200\}$) of the warm component and cold component were determined. The ratios $I_\nu(200)/A_V$ and $\tau\{200\}/ A_V$ of the cold component indicate changes in the optical properties of the dust grains, with an enhanced far-infrared emissivity with respect to the big grains in the diffuse interstellar medium. Comparisons of the emissions and $\tau\{200\}$of the cold component with carbon monoxide measurements, which trace the molecular gas, were carried out. The cold component emission correlates very well with $^{13}CO$ (J=1-0) total intensity. Very good correlations between $C^{18}O$ (J=1-0) total intensity and especially $\tau\{200\}$ are found for two distinct regions, one that encloses the core TMC-2 and the other that corresponds to the northern region and also contains molecular condensations. These results confirm $\tau(200)$ as a powerful tracer of dense cores with $n(H_2) \approx 10^{4}\$ cm^{-3}$, and that the change in the properties of dust grains takes place at densities of $n(H_2) \approx 10^{3}$ cm$^{-3}$.

Far-infrared observations have also been presented between 60 and 200 μm and a near-infrared extinction map of the small moderately dense cloud LDN 1780. For an angular resolution of 4′ the visual extinction maximum is $A_V$ =4.4 mag. ISOPHOT data and a new release of IRAS data have been used to separate the emission from the *warm* and *cold* components of large dust grains. It has been shown that these components are spatially separated, with the cold component surrounded by the warm component. The cold component is well correlated with the $^{13}CO$ (J=1-0) line integrated $W_{13}$ that trace molecular gas at densities of $10^3$ $cm^{-3}$. The warm component has a uniform colour temperature of around 25±1K (assuming β=2), and the colour temperature of the cold component slightly varies between ~15.8-17.3K (β=2, ΔT=0.5K). The ratio between the emission at 200 μm of the cold component and $A_V$ is $I_\nu(200)/A_V$=12.1±0.7 MJy $sr^{-1}$ $mag^{-1}$. The Hα emission ($I_\nu$(Hα) and $A_V$ correlate very well; a ratio $I_\nu(H\alpha)/A_V$ = 2.2±0.1 Rayleigh $mag^{-1}$ is observed. The Hα emission of the diffuse local background of LDN 1780 of ~1.4 Rayleigh is likely due to the ionisation from OB stars of the Galactic midplane and the Scorpius-Centaurus OB association. In the cloud itself, the very good correlation between the Hα emission and the extinction for a relatively large range of column densities is likely due to the presence of a source of ionisation that can penetrate very deep into the cloud. It is suggested that the Hα emission is a result of ionisation of cosmic ray particles and extended red emission due to silicon nanoparticles.



**HESS**
***L. Drury***

The HESS (High Energy Stereoscopic System) collaboration of which DIAS is a member continued a very successful year of observations and published some 16 major refereed publications (including two in the journal Science). Of particular significance was the detection of another spatially resolved shell-type SNR, RXJ0852.0-4622 (the so-called Vela Junior) in addition to RXJ1713-3942.

**The Mid-Infrared Instrument (MIRI) for the James Webb Space Telescope**
***T.P. Ray and E. Flood***

MIRI, the Mid-Infrared Instrument for the James Webb Space Telescope(JWST), will provide imaging and spectroscopy at wavelengths from 5 to 27 microns. It is an international collaboration between the European Space Agency and NASA. DIAS is part of an international consortium of European partners building the optics modules. NASA/JPL will supply the cryostat to cool the optics as well as the detectors.


**Completing the MIRI Structural Model at the Rutherford Appleton Laboratory**

Production of the imager filters and the dichroics for the spectrograph are progressing well under a DIAS contract with the Infrared Multilayer Laboratory at the University of Reading. The various filters are produced in batch mode that includes not only specimens for the Demonstration and Virtual Models (DM and VM respectively) but also the Flight Model (FM). Radiation testing has been performed by ESA on all filter materials to check for out-gassing and radiation damage.

Some oxidising of two filters for the imager and coronagraph was noted. In both cases germanium had been used to strengthen the multilayer. As the oxidising resulted in a loss of transmission, experiments are ongoing to seal the filters in parylene. If successful these filters will be remanufactured. Structural testing of MIRI at the Rutherford Appleton Laboratory went well.

**Dublin Numerical Simulations Group**
***A. Lim***

A. Lim has undertaken to create and manage a Dublin-wide "club" of those researchers involved in numerical simulations in astrophysics (some interest has also come from the Geophysics Section). This group includes workers from DIAS, TCD and DCU and will meet at DIAS roughly once a fortnight to discuss current research, work on common or individual problems, and coordinate research efforts. Initial consultations have also raised the possibility of producing a code library of well-tested algorithms (e.g. for atomic/molecular cooling, or the solution of Riemann problems) for general use. The first meetings are expected early in the new year.

**CosmoGrid and ICHEC**
***L. Drury and T. Lery***

DIAS and CosmoGrid are founding members of the consortium, which established the Irish Centre for High End Computing with two seats on the interim board of the centre. During the year CosmoGrid, with the agreement of the HEA, agreed to contribute 700,000Euro towards the initial equipment purchase of ICHEC in return for access to 40% of ICHEC's facilities and part ownership of the "Walton" cluster.

**Understanding Jets through Simulation, Experiment and Theory (JETSET)**

*T.P. Ray, T. Lery, F. de Colle, E. Whelan and E. Flood*

**The JETSET Team assembled in Villard de Lans, France**

JETSET is a four-year Marie Curie Research Training Network (RTN) designed to build an interdisciplinary European research and training community centred on the study of jets, with a focus on outflows produced during stellar birth. The network brings together workers in the fields of astrophysical observations, theoretical and computational modelling, laboratory experiments, and Grid technology. JETSET is coordinated by DIAS and its creation has led to twenty new postdoctoral (Experienced Researcher) and postgraduate (Early Stage Researcher) positions in the ten partner institutions.

Commencement of the project began in February 2005 with a two-day kick-off meeting held in Rome Observatory. By the end of the year virtually all of the Experienced and Early Stage Researcher posts were filled .

## Hamilton Bicentenary

Special significance attached to the annual Hamilton walk from Dunsink Observatory to Broome Bridge because 2005, the bicentenary of his birth, was declared by the Irish Government to be “Hamilton Year celebrating Irish Science”. To mark the occasion an Irish oak tree was planted in the grounds of Dunsink by Hamilton’s closest known living descendent, Michael Rowan Hamilton John O’Regan and the Nobel prize winning physicist, Stephen Weinberg.

## Travel

**L. Drury** Last SSAC Meeting Paris, 20-21 January; HESS Working Group Meeting Heidelberg, 9-12 February; Workshop on SNRs – Invited Talk, Berlin, 7-9 April; Seminar in Oxford Astrophysics Department, 24-25 May; Conference Torun, Poland, 18-24 June; 29th ICRC Conference, Pune, 1-24 August; Colloquium in Albert Einstein Potsdam, 22-29 September; Representing Ireland at 28th ICSU General Assembly
Shanghai, 17-22 October;

**T. Ray** Optical Spectroscopy Meeting – RAS London, 14-16 January; Imperial College London and JETSET Kick-Off Meeting in Rome University, Rome, 18-23 February; Seminar in the University of Sussex; 4 March; Attending and presenting work at Protostars & Planets V Conference, Kona, Hawaii, 19-31 October

**T. Lery** Cosmogrid Conference and Courses, Galway, Ireland, 18-21 Jan., JETSET Kick-Off Meeting, Rome, 20-23 February; Cosmogrid/ICHEC visit to IBM research Labs in Watson, US, 6-8 March; Invited talk at the French Institute for Laser and Plasma (ILP) Conference, Autrans, France, 15-17 March; Cosmogrid Project Scientist visit to Galway, 7 April; Organisation of IDL courses and Cosmogrid-ASGI joint conference in Galway, 19-22 April; DEISA Kick-off meeting, Paris, France, 9-10 May; Invited talk at a conference entitled "Grids and the Virtual Observatory", Strasbourg Observatory, France, 7-8 June; International HPC Conference, Heidelberg, Gremany, 21-24 June; IBM worldwide EMEA conference, 14-15 Sept.; HPC project presentation, DCU, 20 Sept.; HPC project presentation, UCC and Tyndall Institute, 26 Sept.; HPC project presentation, UCD, 28 Sept.; BlueGene Consortium Meeting, Edinburgh, UK, 4-6 October; HPC project presentation, DIT and RCSI, 10 Oct.; Attending and presenting work at Protostars & Planets V Conference, Kona, Hawaii, 24-28 October; Cosmogrid/ICHEC visit to IBM research Labs, Watson, US, 21-27 November; EU research Infrastructure Conference, Nottingham 6-7 December;

**D. Froebrich** Giving a talk at ASGI Cosmo Grid meeting, Galway, 20-23 April; Work with J. Eislöffel in Tautenburg, Germany, 4-17 May; Copy the GSC2.3 catalogue and work with M.D. Smith, Armagh, 27 June; Observtion at UKIRT (5 nights) and work with C. Davis (JAC), K.W. Hoolapp (IPA) 5 days, Hilo, Hawaii, 8-27 August; Participation at Protostars & Planets V Conference in Hawaii and work and gave seminar in Toronto with A. Scholz

**D. Coffey** ASGI Conference & IDL Workshop, Galway, 18-22 April

**R. Curran** Observing trip, Hawaii, 11-22 April; Protostars & Planets Conference, Hawaii, 21 October – 02 November

**G Murphy** RAS Meeting on Computational Astrophysics, London, 11 February; Talk at ASGI Meeting on YSO Jet Propagation, Galway, 20-23 April;
Institute for Pure and Applied Mathematics Meeting "Astrophysical Fluid Dynamics, Los Angeles, 04-09 April; Scientific collaboration within the context of HPC Europa, Bologna, 16 August – 22 September; Protostars & PlanetsV Conference, Hawaii, 21-29 October

**E. Whelan** Visit to Osservatorio Astrofisico di Arcetri for collaboration work and seminar, Florence, 21 May – 02 June; Collaborative work with Paulo Garcia, JETSET node, 8-13 November

**C. Combet** Collaboration with D. Maurin and E. Vangioni-Flam at the Institut d'Astrophysique de Paris, 09-14 February; Institute for Pure and Applied Mathematics Meeting "Astrophysical Fluid Dynamics, Los Angeles, 04-09 April; Protostars and Planets V Conference, Hawaii, 21 October – 04 November;

**E. Flood** JETSET Kick-Off Meeting, Rome, 20-22 February

**S. Dudzinski** Sysadmin Conference (Fosden 2005), Brussels, 25-27 February;

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Aharonian, F., … Drury, L.~O'C., …: Discovery of extended VHE gamma-ray emission from the asymmetric pulsar wind nebula in MSH 15-52 with HESS, Astronomy and Astrophysics, **435**, L17-L20

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Aharonian, F., … Drury, L. O'C., …: A search for very high energy γ-ray emission from the starburst galaxy NGC 253 with HESS, Astronomy and Astrophysics, **442**, 177-183

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Aharonian, F., … Drury, L. O'C., …: A possible association of the new VHE γ-ray source HESS J1825 137 with the pulsar wind nebula G 18.0 0.7, Astronomy and Astrophysics, **442**, L25-L29

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Del Burgo, C. and Laureijs, R.~J.: New insights into the dust properties of the Taurus molecular cloud TMC-2 and its surroundings, Monthly Notices of the Royal Astronomical Society, **360**, 901-914

Dolcini, A., … and Meurs, E.: Multiband photometry of the blazar PKS 0537-441: a major active state in December 2004-March 2005, Astronomy and Astrophysics, **443**, L33-L36

Fiore, F., …, Meurs, E.J.A., Ward, P., …: A Flash in the Dark: UVES Very Large Telescope High-Resolution Spectroscopy of Gamma-Ray Burst Afterglows,

Froebrich, D., Scholz, A., Eislöffel, J., and Murphy, G.C.: Star formation in globules in IC 1396, Astronomy and Astrophysics, **432**, 575-584

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Maoiléidigh, Cóilín O'., Meurs, Evert J.A., and Norci, Laura: On the feasibility of detection of neutron star companions to OB runaways using Gaia astrometry, New Astronomy, 10, 591-601

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Chrysostomou, A., Bacciotti, F., Nisini, B., Ray, T.P., Eislöffel, J., Davis, C.J., and Takami, M.: The Transport of Angular Momentum from YSO Jets, Protostars and Planets V, 8156

Coffey, D.A., Bacciotti, F., Woitas, J., Ray, T.P., and Eislöffel, J.: T Tauri Jet Rotation Revealed by Optical and NUV HST/STIS Spectra, Protostars and Planets V, 8032

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