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Abstracts of recently accepted papers

Multi-wavelength observations of the star forming region in L1616

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We present the results of a multi-wavelength study of the star forming region in L1616. Our observations include ROSAT All-Sky Survey (RASS) and High Resolution Imager (HRI) X-ray observations, optical wide-field imaging and near-IR imaging data and optical long-slit and multi-object spectroscopic follow-up. 22 new low-mass pre-main sequence (PMS) stars are found to be distributed mainly to the East of the L1616 cometary cloud, in about a one-square-degree field. We find that the class-III infrared sources outnumber the class-II infrared sources by a factor of about three. The X-ray properties of the PMS stars in L1616 are quite similar to those of PMS stars detected in the Orion Nebula Cluster. The comparison of the position of the L1616 PMS stars in the HR diagram with theoretical PMS evolutionary tracks yields an average age of 1-2 Myr, with a very small age spread of about 1 Myr. Unlike the fossil star forming regions in Orion, L1616 appears to be a region of on-going star formation relatively far from the Orion A and B clouds. Given the small age spread, the spatial distribution of the PMS stars relative to the head of the cloud, as well as its cometary shape and high star formation efficiency, we conclude that the star formation in L1616 was most likely induced by a single event, the impact of the winds of the massive stars of the Orion OB association or a supernova explosion being the possible triggers. The Initial Mass Function (IMF) in L1616 is roughly consistent with that of the field in the mass range $0.3 < M/M_{\odot} < 2.5$. Several faint objects, detected in our optical images, are good candidates for young Brown Dwarfs (BDs). We might expect the number of BDs in L1616 to be intermediate between Taurus and the Trapezium.

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ftp://ftp.na.astro.it/pub/jmae/L/alca0495.ps.gz

On the origin of ionizing photons emitted by T Tauri stars

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We address the issue of the production of Lyman continuum photons by T Tauri stars, in an attempt to provide constraints on theoretical models of disc photoionization. By treating the accretion shock as a hotspot on the stellar surface we show that Lyman continuum photons are produced at a rate approximately three orders of magnitude lower than that produced by a corresponding black body, and that a strong Lyman continuum is only emitted for high mass accretion rates. When our models are extended to include a column of material accreting on to the hotspot we find that the accretion column is extremely optically thick to Lyman continuum photons. Further, we find that radiative recombination of hydrogen atoms within the column is not an efficient means of producing photons with energies greater than 13.6eV, and find that an accretion column of any conceivable height suppresses the emission of Lyman continuum photons to a level below or comparable to that expected from the stellar photosphere. The photospheric Lyman continuum is itself much too weak to affect disc evolution significantly, and we find that the Lyman continuum emitted by an accretion shock is similarly unable to influence disc evolution significantly. This result has important consequences for models which use photoionization as a mechanism to drive the dispersal of circumstellar discs, essentially proving that an additional source of Lyman continuum photons must exist if disc photoionization is to be significant.

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L1157: Interaction of the molecular outflow with the Class 0 environment

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We present high angular resolution interferometric observations of the dust continuum at 2.7 and 1.3 mm, and of the HC_3N (J=12→11) and $C^{18}O$ (J=2→1) emission around L1157-mm, a Class 0 object that drives a spectacular molecular outflow. The millimeter dust emission is clearly resolved into two components, a flattened compact source of $\sim$450×250 AU at 1.3 mm, and mass $\sim$0.1 $M_\odot$, plus an extended envelope of $\sim$3000 AU at 1.3 mm, and mass $\sim$1.1 $M_\odot$. The millimeter spectral index varies throughout the region, with the lower value found toward the compact protostar, possibly indicating grain growth in the denser regions. A strong interaction between the molecular outflow and the close protostellar environment is taking place and affects the structure of the innermost parts of the envelope. This is shown by the spatial coincidence between the molecular outflow and the dust (1.3 mm continuum) and HC_3N emission: both tracers show structures associated to the edges of the outflow lobes. Basically, the global picture sketched for the Class 0 object L1157-mm by Gueth et al. (1997) is supported. We find possible evidence of infall, but we do not detect any velocity gradient indicative of a rotating circumstellar disk.

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http://www.arcetri.astro.it/~mbeltran/l1157.ps

Rotating disks in high-mass young stellar objects

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We report on the detection of four rotating massive disks in two regions of high-mass star formation. The disks are perpendicular to known bipolar outflows and turn out to be unstable but long lived. We infer that accretion onto the embedded (proto)stars must proceed through the disks with rates of $\sim 10^{-2}$ $M_\odot$ yr^{-1}.

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Massive star formation: Nurture, not nature

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We investigate the physical processes which lead to the formation of massive stars. Using a numerical simulation of the formation of a stellar cluster from a turbulent molecular cloud, we evaluate the relevant contributions of fragmentation and competitive accretion in determining the masses of the more massive stars. We find no correlation between the final mass of a massive star, and the mass of the clump from which it forms. Instead, we find that the bulk of the mass of massive stars comes from subsequent competitive accretion in a clustered environment. In fact, the majority of this mass infalls onto a pre-existing stellar cluster. Furthermore, the mass of the most massive star in a system increases as the system grows in numbers of stars and in total mass. This arises as the infalling gas is accompanied by newly formed stars, resulting in a larger cluster around a more massive star. High-mass stars gain mass as they gain companions, implying a direct causal relationship between the cluster formation process, and the formation of higher-mass stars therein.

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Rotation of Jets from Young Stars: New Clues from the Hubble Space Telescope Imaging Spectrograph

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We report findings from the first set of data in a current survey to establish conclusively whether jets from young stars rotate. We observed the bi-polar jets from the T Tauri stars TH28 and RW Aur, and the blue-shifted jet from T Tauri star LkHα321, using the Hubble Space Telescope Imaging Spectrograph (HST/STIS). Forbidden emission lines (FELs) show distinct and systematic velocity asymmetries of 10 – 25 ($\pm$ 5) km s^{-1} at a distance of 0.3 arcsec from the source, representing a (projected) distance of $\approx$ 40 AU along the jet in the case of RW Aur, $\approx$ 50 AU for TH28, and 165 AU in the case of LkHα321. These velocity asymmetries are interpreted as rotation in the initial portion of the jet where it is accelerated and collimated. For the bi-polar jets, both lobes appear to rotate in the same direction. Values obtained were in agreement with the predictions of MHD disk-wind models (Bacciotti et al. 2002, Anderson et al. 2003, Dougados et al. 03, Pesenti et al. 2003). Finally, we determine, from derived toroidal and poloidal velocities, values for the distance from the central axis of the footpoint for the jet's low velocity component of $\approx$ 0.5 - 2 AU, consistent with the models of magneto-centrifugal launching (Anderson et al. 2003).

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Extending the census at the bottom of the stellar mass function in Chamaeleon I

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We present the results of a deep, wide field objective prism survey of the entire Chameleon I cloud, followed by long slit spectroscopy of objects with detected Hα emission that were either previously unidentified, or suspected to be members only on the basis of their mid-infrared emission. We identify 9 new members and confirm 9 objects already suspected as members, with spectral types ranging from late K to M8.5. The latter limit corresponds to an object with an estimated mass of 0.03 $M_\odot$, making it the latest-type brown dwarf spectroscopically confirmed so far in Chamaeleon I. A comparison with theoretical pre-main sequence tracks indicates an age of most of the members between 1 and 5 Myr, consistent with previous studies. However, we find that the objects with Hα equivalent widths exceeding 100 Å tend to have apparent ages above 5 Myr, and in the two most extreme cases their positions in the temperature-luminosity diagram, if interpreted at face value, would place them below the main sequence. These two extreme objects display surprising differences in their emission line spectra in spite of the otherwise very similar broad-band spectral energy distributions and spectral types, being strongly dominated by accretion-tracing and outflow-tracing emission lines, respectively. We interpret the identification of an apparently underluminous object with strong accretion signatures and only weak outflow signatures as a further support, already discussed in previous works, for the apparent underluminosity of objects with very large Hα equivalent widths being a real, intrinsic feature rather than being due to partial blocking by an edge-on disk. Given that Hα emission is the most common feature among young stellar objects we consider that the present work is an important contribution towards a complete census of the Chamaeleon I star forming region down to the hydrogen-burning limit.

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http://www.eso.org/~fcomeron/cham_wide.ps

Stationary accretion disks launching super fast-magnetosonic MHD jets

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We present self-similar models of resistive viscous Keplerian disks driving non-relativistic magnetohydrodynamics (MHD) jets becoming super fast-magnetosonic. We show that in order to obtain such solutions, the thermal pressure must be a sizeable fraction of the poloidal magnetic pressure at the Alfvén surface. These steady solutions which undergo a recollimation shock causally disconnected from the driving engine, account for structures with a high temperature plasma in the sub-Alfvénic region. We suggest that only unsteady outflows with typical time-scales of several disk dynamical time-scales can be produced if the suitable pressure conditions are not fulfilled.

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Multiepoch Radio Observations of the Exciting Sources of HH 212 and HH 119

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We present high angular resolution ($\sim 0\farcs3$) Very Large Array observations at 3.5 cm toward the regions of the exciting sources of two Herbig-Haro systems, namely, HH 212 in Orion and HH 119 in B335. The observations were made at three different epochs to search for possible fast time variations in the sources (in the scale of one week to one month). In HH 212 we detected, averaging the observations of the three epochs, a faint object, at the expected position for the exciting source of the HH system. Comparison with other radio observations indicate that this source exhibits considerable time variation in a scale of years. In B335 we detected at each epoch the source previously reported by other authors and our results suggest that this object, a thermal radio jet, is variable in timescales of a month. We discuss possible explanations for this fast variability.

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http://www.astrosmo.unam.mx/~l.rodriguez/publ.html

Monte Carlo radiative transfer in molecular cloud cores

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We present the results of a three-dimensional Monte Carlo radiative transfer code for starless molecular cloud cores heated by an external isotropic or non-isotropic interstellar radiation field. The code computes the dust temperature distribution inside model clouds with specified but arbitrary density profiles. In particular we examine in detail spherical (Bonnor-Ebert) clouds, axisymmetric and non-axisymmetric toroids, and clouds heated by an external stellar source in addition to the general interstellar field. For these configurations, the code also computes maps of the emergent intensity at different wavelengths and arbitrary viewing angle, that can be compared directly with continuum maps of prestellar cores. In the approximation where the dust temperature is independent of interactions with the gas and where the gas is heated both by collisions with dust grains and ionization by cosmic rays, the temperature distribution of the gas is also calculated. For cloud models with parameters typical of dense cores, the results show that the dust temperature decreases monotonically from a maximum value near the cloud's edge (14–15 K) to a minimum value at the cloud's center (6–7 K). Conversely, the gas temperature varies in a similar range, but, due to efficient dust-gas coupling in the inner regions and inefficient cosmic-ray heating in the outer regions, the gradient is non-monotonic and the gas temperature reaches a maximum value at intermediate radii. The emission computed for these models (at 350 μm and 1.3 mm) shows that deviations from spherical symmetry in the density and/or temperature distributions are generally reduced in the simulated intensity maps (even without beam convolution), especially at the longer wavelengths.

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A Near-Infrared Multiplicity Survey of Class I/Flat-Spectrum Systems in Six Nearby Molecular Clouds

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We present new near-IR observations of 76 Class I/flat-spectrum objects in the nearby ($d \leq 320$ pc) Perseus, Taurus, Chamaeleon I and II, ρ Ophiuchi, and Serpens dark clouds. These observations are part of a larger systematic infrared multiplicity survey of self-embedded objects in the nearest dark clouds. When combined with the results of our previously published near-infrared multiplicity survey, we find a *restricted* companion star fraction of 14/79 (18% $\pm$ 4%) of the sources surveyed to be binary or higher order multiple systems over a separation range of $\sim 300 - 2000$ AU with a magnitude difference $\Delta K \leq 4$, and with no correction for background contamination or completeness. This is consistent with the fraction of binary/multiple systems found among older pre-main-sequence T Tauri stars in each of the Taurus, ρ Ophiuchi, and Chamaeleon star-forming regions over a similar separation range, as well as the combined companion star fraction for these regions. However, the companion star fraction for solar-type main-sequence stars in the solar neighborhood in this separation range (11% $\pm$ 3%) is approximately one-half that of our sample. Together with multiplicity statistics derived for previously published samples of Class 0 and Class I sources, our study suggests that a significant number of binary/multiple objects may remain to be discovered at smaller separations among our Class I/flat-spectrum sample and/or most of the evolution of binary/multiple systems occurs during the Class 0 phase of early stellar evolution.

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A Photometric Study of Stars in the MBM 12 Association

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We have monitored four fields containing nine previously identified members of the MBM 12 association to search for photometric variability and periodicity in these pre-main sequence stars. Seven of the nine are found to be variable and definite periodicity (of 1.2, 2.6 and 6.2 days) is found for three of them, including the classical T Tauri star LkHα 264. Two other members are possibly periodic but each requires confirmation. In addition, a "field" star that is associated with the X-ray source RX J0255.9+2005 was discovered to be a variable with a period of 4.2 days. Our results indicate that the photometric variability characteristics of the known MBM 12 association members are typical of what is found in ~few My old stellar groups such as IC 348, supporting arguments for a similar age. In particular, there is a mix of periodic and non-periodic variables with typical amplitudes (in Cousins I) of 0.1-0.5 mag, in addition to a small number of larger amplitude variables. The periods, as a group, are somewhat shorter than in IC 348 but when allowance is made for the known dependence of period on mass in pre-main sequence stars the difference may not be significant. Our data confirm and illustrate the value of photometric monitoring as a tool for identifying likely association members and for studying rotation in extremely young stellar groups.

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An Assessment of Dynamical Mass Constraints on Pre-Main Sequence Evolutionary Tracks

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We have assembled a database of stars having both masses determined from measured orbital dynamics and sufficient spectral and photometric information for their placement on a theoretical HR diagram. Our sample consists of 115 low mass ($M < 2.0$ M$_\odot$) stars, 27 pre-main sequence and 88 main sequence. We use a variety of available pre-main sequence evolutionary calculations to test the consistency of predicted stellar masses with dynamically determined masses. Despite substantial improvements in model physics over the past decade, large systematic discrepancies still exist between empirical and theoretically derived masses. For main-sequence stars, all models considered predict masses consistent with dynamical values above 1.2 M$_\odot$, some models predict consistent masses at solar or slightly lower masses, and no models predict consistent masses below 0.5 M$_\odot$ but rather all models systematically under-predict such low masses by 5-20%. The failure at low masses stems from the poor match of most models to the empirical main-sequence below temperatures of 3800 K where molecules become the dominant source of opacity and convection is the dominant mode of energy transport. For the pre-main sequence sample we find similar trends. There is generally good agreement between predicted and dynamical masses above 1.2 M$_\odot$ for all models. Below 1.2 M$_\odot$ and down to 0.3 M$_\odot$ (the lowest mass testable) most evolutionary models systematically under-predict the dynamically determined masses by 10-30% on average with the Lyon group models (e.g. Baraffe et al. 1998) predicting marginally consistent masses *in the mean* though with large scatter. Over all mass ranges, the usefulness of dynamical mass constraints for pre-main sequence stars is in many cases limited by the *random* errors caused by poorly determined luminosities and especially temperatures of young stars. Adopting a warmer-than-dwarf temperature scale would help reconcile the *systematic* pre-main sequence offset at the lowest masses, but the case for this is not compelling given the similar warm offset at older ages between most sets of tracks and the empirical main sequence. Over all age ranges, the systematic discrepancies between track-predicted and dynamically determined masses appear to be dominated by inaccuracies in the treatment of convection and in the adopted opacities.

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http://www.astro.caltech.edu/~lah/papers.html

Tracing the Magnetic Field in Orion A

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We use extensive 350 μm polarimetry and continuum maps obtained with Hertz and SHARC II along with HCN and HCO^+ spectroscopic data to trace the orientation of the magnetic field in the Orion A star-forming region. Using the polarimetry data, we find that the direction of the projection of the magnetic field in the plane of the sky relative to the orientation of the integral-shaped filament varies considerably as one moves from north to south. While in IRAS 05327-0457 and OMC-3 MMS 1-6 the projection of the field is primarily perpendicular to the filament it becomes better aligned with it at OMC-3 MMS 8-9 and well aligned with it at OMC-2 FIR 6. The OMC-2 FIR 4 cloud, located between the last two, is a peculiar object where we find almost no polarization. There is a relatively sharp boundary within its core where two adjacent regions exhibiting differing polarization angles merge. The projected angle of the field is more complicated in OMC-1 where it exhibits smooth variations in its orientation across the face of this massive complex. We also note that while the relative orientation of the projected angle of the magnetic field to the filament varies significantly in the OMC-3 and OMC-2 regions, its orientation relative to a fixed position on the sky shows much more stability. This suggests that, perhaps, the orientation of the field is relatively unaffected by the mass condensations present in these parts of the molecular cloud. By combining the polarimetry and spectroscopic data we were able to measure a set of average values for the inclination angle of the magnetic field relative to the line of sight. We find that the field is oriented quite close to the plane of the sky in most places. More precisely, the inclination of the magnetic field is $\approx 73^\circ$ around OMC-3 MMS 6, $\approx 74^\circ$ at OMC-3 MMS 8-9, $\approx 80^\circ$ at OMC-2 FIR 4, $\approx 65^\circ$ in the northeastern part of OMC-1, and $\approx 49^\circ$ in the Bar. The small difference in the inclination of the field between OMC-3 and OMC-2 seems to strengthen the idea that the orientation of the magnetic field is relatively unaffected by the agglomeration of matter located in these regions. We also present polarimetry data for the OMC-4 region located some $13'$ south of OMC-1.

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Molecular inventories and chemical evolution of low-mass protostellar envelopes

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This paper presents the first substantial study of the chemistry of the envelopes around a sample of 18 low-mass pre- and protostellar objects for which physical properties have previously been derived from radiative transfer modeling of their dust continuum emission. Single-dish line observations of 24 transitions of 9 molecular species (not counting isotopes) including HCO^+, N_2H^+, CS, SO, SO_2, HCN, HNC, HC_3N and CN are reported. The line intensities are used to constrain the molecular abundances by comparison to Monte Carlo radiative transfer modeling of the line strengths. In general the nitrogen-bearing species together with HCO^+ and CO cannot be fitted by a constant fractional abundance when the lowest excitation transitions are included, but require radial dependences of their chemistry since the intensity of the lowest excitation lines are systematically underestimated in such models. A scenario is suggested in which these species are depleted in a specific region of the envelope where the density is high enough that the freeze-out timescale is shorter than the dynamical timescale and the temperature low enough that the molecule is not evaporated from the icy grain mantles. This can be simulated by a "drop" abundance profile with standard (undepleted) abundances in the inner- and outermost regions and a drop in abundance in between where the molecule freezes out. An empirical chemical network is constructed on the basis of correlations between the abundances of various species. For example, it is seen that the HCO^+ and CO abundances are linearly correlated, both increasing with decreasing envelope mass. This is shown to be the case if the main formation route of HCO^+ is through reactions between CO and H_3^+, and if the CO abundance still is low enough that reactions between H_3^+ and N_2 are the main mechanism responsible for the removal of H_3^+. Species such as CS, SO and HCN show no trend with envelope mass. In particular no trend is seen between "evolutionary stage" of the objects and the abundances of the main sulfur- or nitrogen-containing species. Among the nitrogen-bearing species abundances of CN, HNC and HC_3N are found to be closely correlated, which can be understood from considerations of the chemical network. The CS/SO abundance ratio is found to correlate with the abundances of CN and HC_3N, which may reflect a dependence on the atomic carbon abundance. An anti-correlation is found between the deuteration of HCO^+ and HCN, reflecting different temperature dependences for gas-phase deuteration mechanisms. The abundances are compared to other protostellar environments. In particular it is found that the abundances in the cold outer envelope of the previously studied class 0 protostar IRAS 16293-2422 are in good agreement with the average abundances for the presented sample of class 0 objects.

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A Rotational and Variability Study of a Large Sample of PMS Stars in NGC 2264

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We present the results of an extensive search for periodic and irregular variable pre-main sequence (PMS) stars in the young (2–4 Myr) open cluster NGC 2264, based on photometric monitoring using the Wide Field Imager (WFI) on the 2.2 m telescope on La Silla (Chile). In total, about 10600 stars with I_C magnitudes between 9.8 mag and 21 mag have been monitored in our $34' \times 33'$ field. Time series data were obtained in the I_C band in 44 nights between Dec. 2000 and March 2001; altogether we obtained 88 data points per star. Using two different time series analysis techniques (Scargle periodogram and CLEAN) we found 543 periodic variable stars with periods between 0.2 days and 15 days. Also, 484 irregular variable stars were identified using a χ^2-test. In addition we have carried out nearly simultaneous observations in V, R_C and a narrow-band Hα filter. The photometric data enable us to reject background and foreground stars from our sample of variable stars according to their location in the I_C vs $(R_\mathrm{C} - I_\mathrm{C})$ colour-magnitude and $(R_\mathrm{C} - H\alpha)$ vs $(R_\mathrm{C} - I_\mathrm{C})$ colour-colour diagrams. We identified 405 periodic variable and 184 irregular variable PMS stars as cluster members using these two different tests. In addition 35 PMS stars for which no significant variability were detected could be identified as members using an $H\alpha$ emission index criterion. This yields a total of 624 PMS stars in NGC 2264, of which only 182 were previously known. Most of the newly found PMS stars are fainter than $I_\mathrm{C} \simeq 15$ mag and of late spectral type ($\gtrsim$M2). We find that the periodic variables, as a group, have a smaller degree of variability and smaller $H\alpha$ index than the irregular variables. This suggests that the sample of periodic variables is biased towards weak-line T Tauri stars (WTTSs) while most of the irregular variables are probably classical T Tauri stars (CTTSs). We have quantified this bias and estimated that the expected fraction of WTTSs among PMS stars in the cluster is 77%. This is relatively close to the fraction of WTTSs among the periodic variables which is 85%. We also estimated the total fraction of variables in the cluster using only two well selected concentrations of PMS stars called NGC 2264 N & S in which we can easily estimate the total number of PMS stars. We find that at least 74% of the PMS stars in the cluster with $I_\mathrm{C} \leq 18.0$ mag were found to be variable (either periodic or irregular) by our study. This number shows that our search for PMS stars in NGC 2264 through extensive and accurate photometric monitoring is very efficient in detecting most PMS stars down to at least $I_\mathrm{C} = 18.0$ mag.

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The Formation of Self-Gravitating Cores in Turbulent Magnetized Clouds

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We use ZEUS-MP to perform high resolution, three-dimensional, super-Alfvénic turbulent simulations in order to investigate the role of magnetic fields in self-gravitating core formation within turbulent molecular clouds. Statistical properties of our super-Alfvénic model without gravity agree with previous similar studies. Including self-gravity, our models give the following results. They are consistent with the turbulent fragmentation prediction of the core mass distribution of Padoan & Nordlund. They also confirm that local gravitational collapse is not prevented by magnetohydrodynamic waves driven by turbulent flows, even when the turbulent Jeans mass exceeds the mass in the simulation volume. Comparison of results between 256^3 and 512^3 zone simulations reveals convergence in the collapse rate. Analysis of self-gravitating cores formed in the simulation shows that: (1) All cores formed are magnetically supercritical by at least an order of magnitude. (2) A power law relation between central magnetic field strength and density $B_c \propto \rho_c^{1/2}$ is observed despite the cores being strongly supercritical. (3) Specific angular momentum $j \propto R^{3/2}$ for cores with radius R. (4) Most cores are prolate and triaxial in shape, in agreement with the results of Gammie et al. We find a weak correlation between the minor axis of the core and the local magnetic field in our simulation at late times, different from the uncorrelated results reported by Gammie et al. The core shape analysis and the power law relationship between core mass and radius $M \propto R^{2.75}$ suggest the formation of some highly flattened cores. We identified twelve cloud cores with disk-like appearance at a later stage of our high-resolution simulation. Instead of being tidally truncated or disrupted, the core disks survive and flourish while undergoing strong interactions. We discuss the physical properties of these disk-like cores under the constraints of resolution limits.

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Discovery of an optical jet in the Rosette Nebula: Rosette HH2

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We report on the discovery of an optical jet – Rosette HH2 – in the Rosette Nebula. The jet system bears unique features for residing at the center of a giant HII region, and its energy source is visible with apparently very low extinction along the line of sight. Unlike most other Herbig-Haro jets, this jet indicates a high-excitation origin and its extended portion shows a seemingly intact structure instead of normally a shocked working surface, which is attributed to photoablation.

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http://www.chjaa.org/

Periodic Variability of Pre-Main Sequence Stars in the NGC 2264 OB Association

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We summarize the results of an observing campaign to identify periodic pre-main-sequence variables in the NGC 2264 OB association. We find 201 periodic candidates. The mean age of the NGC 2264 periodic variables is approximately 30% greater than their counterparts in the Orion Nebula Cluster. Given the difference in mean age between NGC 2264 and Orion, we expect the typical periodic variable in NGC 2264 to have a period shorter by a factor of ∼1.6, if the initial distribution of periods in the two clusters is identical and if stellar angular momentum is conserved. However, we find a period distribution indistinguishable from that found in Orion. This suggests that the angular momenta of a significant fraction of PMS stars in the age range ∼0.4 to ∼4 Myr must be regulated. To examine the hypothesis that disk locking regulates PMS star angular momenta, we use four different disk indicators ($U-V$, $I_{\rm C}-K_{\rm s}$, $H-K_{\rm s}$, and Hα) to search for correlations between period and disk indicator. We find no conclusive evidence that more slowly rotating stars have disk indicators, or that faster-rotating stars are less likely to have disk indicators.

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L183 (L134N) Revisited
II. The dust content

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We present here a complete dust map of L183 (= L134N) with opacities ranging from A_V = 3 to 150 mag. Five peaks are identified as being related to known molecular peaks and among these dust peaks two are liable to form stars. The main peak is a prestellar core with a density profile proportional to r^{-1} up to a radius of ∼4500 A.U. and the northern peak could possibly be on its way to form a prestellar core. If true, this is the first example of the intermediate steps between cloud cores and prestellar cores during the quasi-static contraction. Additionally, the low dust temperature of the core reported in Pagani et al. (2003, A&A 406, L59) is confirmed, and the ISOPHOT data are shown to be inappropriate for finding such cores. In the inner core, $T_{\rm dust} \approx$ 7.5 K and could be as low as 6.7 K.

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http://aramis.obspm.fr/∼pagani/l134n.html

Dynamical Mass Constraints on Low-Mass Pre–Main-Sequence Stellar Evolutionary Tracks: An Eclipsing Binary in Orion with a 1.0 $M_\odot$ Primary and an 0.7 $M_\odot$ Secondary

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We report the discovery of a double-lined, spectroscopic, eclipsing binary in the Orion star-forming region. We analyze the system spectroscopically and photometrically to empirically determine precise, distance-independent masses, radii, effective temperatures, and luminosities for both components. The measured masses for the primary and secondary,

accurate to $\sim 1\%$, are 1.01 $M_\odot$ and 0.73 $M_\odot$, respectively; thus the primary is a definitive pre–main-sequence solar analog, and the secondary is the lowest-mass star yet discovered among pre–main-sequence eclipsing binary systems. We use these fundamental measurements to test the predictions of pre–main-sequence stellar evolutionary tracks. None of the models we examined correctly predict the masses of the two components simultaneously, and we implicate differences between the theoretical and empirical effective temperature scales for this failing. All of the models predict the observed slope of the mass-radius relationship reasonably well, though the observations tend to favor models with low convection efficiencies. Indeed, considering our newly determined mass measurements together with other dynamical mass measurements of pre–main-sequence stars in the literature, as well as measurements of Li abundances in these stars, we show that the data strongly favor evolutionary models with inefficient convection in the stellar interior, even though such models cannot reproduce the properties of the present-day Sun.

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Preprints: http://people.vanderbilt.edu/~keivan.stassun/pubs.htm

Bipolar Molecular Outflows from High-Mass Protostars

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We report observations of the bipolar molecular outflows associated with the luminous ($\sim 2\times10^4$ $L_\odot$) far-IR sources IRAS 21519+5613 and IRAS 22506+5944, as well the dust and molecular gas condensations on which these outflows appear to be centered. The observations were made in ^{12}CO, ^{13}CO, C^{18}O, and continuum at 3 mm with the BIMA-array, and in ^{12}CO and ^{13}CO with the NRAO 12-m telescope to recover extended emission filtered out by the interferometric array. We find that the outflow associated with each IRAS source shows a clear bipolar morphology in ^{12}CO, with properties (i.e., total mass of order $10-100$ $M_\odot$, mass-outflow rate $>10^{-3}$ $M_\odot$, dynamical timescale 10^4-10^5 yrs, and energetics) comparable with those of other massive outflows associated with luminous YSOs. Each outflow appears to be centered on a dust and gas condensation with a mass of $200-300$ $M_\odot$, likely marking the location of the driving source.

The outflow lobes of both sources are fully resolved along their major but not minor axes, and have collimation factors that may be comparable to young low-mass stars. The mass-velocity diagrams of both outflows change in slope at a velocity of $\sim$10 km s^{-1}, suggesting that the high-velocity component (HVC) may drive the low-velocity component (LVC). Although the HVC of IRAS 21519+5613 shows evidence for deceleration, no such signature is seen in the HVC of IRAS 22506+5944. Neither HVCs have a momentum supply rate sufficient to drive their corresponding LVCs, although it is possible that the HVC is more highly excited and hence its thrust underestimated. Like for other molecular outflows the primary driving agent cannot be ionized gas, leaving atomic gas as the other remaining candidate.

Neither IRAS 21519+5613 nor IRAS 22506+5944 exhibit detectable free-free emission, which together with the observed properties of their molecular outflows and surrounding condensations make them credible candidates for high-mass protostars. The mass-accretion rate required to produce their observed IRAS luminosity is $>10^{-4}$ $M_\odot$ yr^{-1}, which is more than sufficient to quench the development of an UC-HII region. On the other hand, the individual IRAS sources may be associated with a group of stars whose dominant member is a main-sequence star that is responsible for the observed outflow. Such a star would be required to have a spectral type of $\sim$B2 (luminosity of $\sim$3000 $L_\odot$) or later to not excite a detectable UC-HII region; the time-averaged mass-accretion rate needed to produce this star is then 10^{-3}–10^{-4} $M_\odot$ yr^{-1}. Thus, regardless of the evolutionary stage of the outflow-driving source, the inferred mass-accretion rate is much higher than that allowed by simple inside-out collapse models but can be accommodated by recently proposed variants.

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http://www.asiaa.sinica.edu.tw/~ynsu/outflow.pdf

On the internal structure of starless cores. I. Physical conditions and the distribution of CO, CS, N_2H^+, and NH_3 in L1498 and L1517B

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We have characterized the physical structure and chemical composition of two close-to-round starless cores in Taurus-Auriga, L1498 and L1517B. Our analysis is based on high angular resolution observations in at least two transitions of NH_3, N_2H^+, CS, $C^{34}S$, $C^{18}O$, and $C^{17}O$, together with maps of the 1.2 mm continuum. For both cores, we derive radial profiles of constant temperature and constant turbulence, together with density distributions close to those of non-singular isothermal spheres. Using these physical conditions and a Monte Carlo radiative transfer model, we derive abundance profiles for all species and model the strong chemical differentiation of the core interiors. According to our models, the NH_3 abundance increases toward the core centers by a factor of several (≈ 5) while N_2H^+ has a constant abundance over most of the cores. In contrast, both $C^{18}O$ and CS (and isotopomers) are strongly depleted in the core interiors, most likely due to their freeze out onto grains at densities of a few 10^4 cm^{-3}. Concerning the kinematics of the dense gas, we find (in addition to constant turbulence) a pattern of internal motions at the level of 0.1 km s^{-1}. These motions seem correlated with asymmetries in the pattern of molecular depletion, and we interpret them as residuals of core contraction. Their distribution and size suggest that core formation occurs in a rather irregular manner and with a time scale of a Myr. A comparison of our derived core properties with those predicted by supersonic turbulence models of core formation shows that our Taurus cores are much more quiescent than allowed by these models. In two appendices at the end of the paper we present a simple and accurate approximation to the density profile of an isothermal (Bonnor-Ebert) sphere, and a Monte Carlo-calibrated method to derive gas kinetic temperatures using NH_3 data.

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Carbon budget and carbon chemistry in Photon Dominated Regions

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We present a study of small carbon chains and rings in Photon Dominated Regions (PDRs) performed at millimetre wavelengths. Our sample consists of the Horsehead nebula (B33), the ρ Oph L1688 cloud interface, and the cometary-shaped cloud IC63. Using the IRAM 30-m telescope, the SEST and the Effelsberg 100-m telescope at Effelsberg., we mapped the emission of CCH, c-C_3H_2 and C_4H, and searched for heavy hydrocarbons such as c-C_3H, l-C_3H, l-C_3H_2, l-C_4H_2 and C_6H. The large scale maps show that small hydrocarbons are present until the edge of all PDRs, which is surprising as they are expected to be easily destroyed by UV radiation. Their spatial distribution reasonably agrees with the aromatic emission mapped in mid-IR wavelength bands. CCH and c-C_3H_2 correlate remarkably well, a trend already reported in the diffuse ISM (Lucas and Liszt 2000). Their abundances relative to H_2 are relatively high and comparable to the ones derived in dark clouds such as L134N or TMC-1, known as efficient carbon factories. The heavier species are however only detected in the Horsehead nebula at a position coincident with the aromatic emission peak around 7 μm. In particular, we report the first detection of C_6H in a PDR. We have run steady-state PDR models using several gas-phase chemical networks (UMIST95 and the New Standard Model) and conclude that both networks fail in reproducing the high abundances of some of these hydrocarbons by an order of magnitude. The

high abundance of hydrocarbons in the PDR may suggest that the photo-erosion of UV-irradiated large carbonaceous compounds could efficiently feed the ISM with small carbon clusters or molecules. This new production mechanism of carbon chains and rings could overcome their destruction by the UV radiation field. Dedicated theoretical and laboratory measurements are required in order to understand and implement these additional chemical routes.

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http://www.lra.ens.fr/~teyssier/carbon_pdr_dt.ps

A High-Resolution Very Large Array Observation of a Protostar in OMC-3: Shock-induced X-ray Emission by a Protostellar Jet

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Using the Very Large Array (VLA) in the A-configuration, we have obtained a high-resolution 3.6 cm map of a hard X-ray source detected by the Chandra X-ray Observatory in a protostellar clump in Orion molecular cloud 3. Two radio continuum sources were detected in the vicinity of the X-ray source, both of which have NIR counterparts. We conclude that these VLA sources are free-free emission produced by shocks in protostellar jets from the NIR class I protostars. Using the centimeter data, we determined the power and orientation of the protostellar jets. The center position of the X-ray emission was found to be ~ 1–$2''$ offset from the exciting sources of the jets, and the displacement is in the direction of the jets and molecular outflows. We discuss the nature of the X-ray emission as the shock-excited plasma at the shock front where the jet propagates through interstellar medium at a speed of $\sim 1000\,\mathrm{km\,s^{-1}}$.

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The Visible and Near-Infrared Dust Opacity Law in the HH 30 Circumstellar Disk

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We present new images of the scattered light disk around HH 30 at 0.44 and 0.81 μm. We model these images and an existing 2.04 μm image using a multiple scattering code, varying and fitting for the disk parameters and the dust opacity ratios at these wavelengths. A wide range of different disk geometries provide adequate fits to the data: *there is no single best-fit geometry.* In particular, the fits cannot resolve the ambiguity between the power law indices in surface density and scale height. On the other hand, the inclination, opacity-mass product, scale height, and to a lesser degree the extinction toward the star are relatively tightly constrained. Despite the ambiguity in geometry, we conclude that the dust opacity in the scattering layers of the outer parts of the HH 30 circumstellar disk drops from 0.44 to 2.04 μm, but by less than in the low-density ISM. The median fit shows a drop by a factor of less than 2. This result is robust to reasonable changes in the disk density distribution. It suggests that moderate grain growth has occurred, but that small grains still dominate the visible and near-infared opacity.

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Paschen beta emission as a tracer of outflow activity from T-Tauri stars, as compared to Optical Forbidden Emission.

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The Paschen beta (1.2822 μm) emission line found in the near-infrared spectra of T-Tauri stars (TTSs) is believed to trace the accretion of material onto the central star. We present spectroscopic data which suggests that this may not always be the case. The technique of spectro-astrometry is used by us to measure positional displacements in the Paβ emission from four T-Tauri stars, namely DG Tau, V536 Aql, LkHα 321 and RW Aur. We also observed the optical forbidden emission from these sources, for example the [SII]$\lambda\lambda$6716, 6731, [OI]$\lambda\lambda$6300, 6363 and [NII]$\lambda\lambda$6548, 6583 lines. Forbidden emission lines are formed in the outflows that accompany the evolution of protostars and so are ideal to use as a comparison to confirm that the measured offsets in the Paβ emission are indeed due to outflowing material. Models based on the magnetospheric accretion theory have been the most successful to date in explaining the origin of atomic hydrogen emission lines. Yet we see that the line profiles of the sources showing displacement in their Paβ emission all have features that the magnetospheric accretion model has so far failed to explain, such as broad full width half maxima, large wings and an absence of red shifted absorption features. The failure of the models to explain the presence of large extended wings in the line profiles is particularly interesting in the context of this study as in all cases it is in the extended wings that we measure offsets in position with respect to the source.

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Compact Radio Sources in Orion: New Detections, Time Variability, and Objects in OMC-1S

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We present the analysis of four 3.6 cm radio continuum archival observations of Orion obtained using the Very Large Array in its A-configuration, with $0''.3$ angular resolution. The observations were made during the period 1994-1997. In a region of $4' \times 4'$, we detect a total of 77 compact radio sources. Of the total of detected sources, 54 are detected in one or more of the individual observations and 36 of these show time variability (by more than 30%) between the observed epochs. A deep image made from averaging all data shows an additional 23 faint sources, in the range of 0.1 to 0.3 mJy. Of the total of 77 sources, 39 are new centimeter detections. However, only 9 of the 77 sources do not have a previously reported counterpart at near-infrared, optical, or X-ray wavelengths. In particular, we detect three faint sources in the OMC-1S region that may be related to the sources that power the multiple outflows that emanate from this part of the Orion nebula.

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http://www.astrosmo.unam.mx/~l.rodriguez/publ.html

Substellar IMF of young open clusters: constraints on the brown dwarf formation process

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Ph.D degree awarded: October 2003

My thesis work deals with the initial mass function (IMF), especially in the brown dwarf regime which was still unexplored a few years ago. This function describes the number of formed stars per mass bin in a given environment and is therefore directly linked to the stellar and substellar formation processes. However the theoretical framework is far from being satisfactory: the brown dwarf formation mecanism is still discussed and the origin of the IMF remains unknown. In order to improve this situation, I determined the mass function of three young open clusters around the stellar/substellar boundary. This allows me to investigate the IMF universality and to compare the observations with the various formation scenarios which have been proposed to date.

After a general introduction on the IMF and brown dwarfs, I present the results I obtained for the Pleiades cluster and for two other clusters of similar age, Blanco 1 and NGC 2516. Very low mass star and brown dwarf candidates are identified from deep wide-field surveys on the basis of their photometric properties. Their cluster membership is then assessed thanks to other observations (photometric and spectroscopic, optical and infrared). From these samples the mass function have been determined and it appears that they are all coherent.

Then, I compare these results with those obtained for other regions having different age and density. Taking into account the cluster dynamical evolution as well as the binarity effect, I find that the observations suggest the IMF is universal in the stellar domain. At fainter masses however, differences have been reported and I discuss the impact of such a result on the theories of star formation.

Finally, I describe the different scenarios proposed to explain the brown dwarf formation and I compare their predictions to the observations. N-Body numerical simulations modelling a cluster dynamical evolution allow me to constrain the kinematic of brown dwarfs at birth. Despite this study two competing scenarios cannot be distinguished and I propose observational tests to do it.

The Young Low-Mass Population of Orion's Belt

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I have conducted a BVRI survey covering $\sim$2.7 deg^2 of the Orion OB1b sub-association, a $\sim$3 Myr old fossil star forming region located in the belt of Orion. I have developed a procedure to use single epoch photometry to estimate the number of pre-main sequence (**PMS**) stars and field stars in the PMS locus as a function of V$-$I color. This is possible in the Orion OB1b sub-association because the low-mass PMS stars occupy a narrow, well defined locus on the color-magnitude diagram (**CMD**) which is brighter than the bulk of the field stars. The PMS locus is most easily detected in cross-sections through the CMD. In control fields away from the OB association, the number of stars falls exponentially along cross-sections through the V$-$I vs. V CMD. In cross-sections through the V$-$I CMD of Orion OB1b the PMS locus is detectable as a clear excess of stars over the expected number of field stars. This excess population follows the predicted isochrone for $\sim$3 Myr old low-mass stars.

I examined three regions in Orion OB1b. The first includes 0.89 deg^2 around σ Ori which covers most of the σ Ori cluster. The second region covers $\sim$1.2 deg^2 of the western belt near ϵ Ori and δ Ori. The final region covers 0.6 deg^2 around ζ Ori. I separated the ζ Ori region from my analysis of the western belt because the ζ Ori region has significant nebula emission and much greater reddening than the other two regions.

In the σ Ori region, I detected $\sim$180 likely members of the σ Orionis cluster with masses between 0.1 $M_\odot$ and 1.0 $M_\odot$. The cluster's radius is 25' to 40' or three to five parsecs for an assumed distance of 440 pc. The cluster has a radial profile which is well fit by a King model with a King radius of $r_0 \leq$1 pc. The central density of the cluster is $\sim$30 stars pc^{-3} in the mass range $0.2 \leq M \leq 1.0$ $M_\odot$. The best fit age of the cluster is $2.6 \pm 0.4 \times 10^6$ year. The σ Orionis cluster is the richest region of Orion OB1b and the only region that where a clustered population has been detected.

The PMS locus for the σ Ori region is quite narrow for stars near 0.8 $M_\odot$, but becomes wider at lower masses. At least part of this width must be due to a combination of the intrinsic variability of the PMS stars, binary stars, and observational errors. Part of this width may be caused by the stars in the cluster having formed over a period of several Myrs. It is impossible to interpret the width of the PMS locus in terms of an age-spread without knowing the expected width of a single age (isochronal) population. I constructed several simulated populations of PMS stars that were either coeval or had a range of ages. I compared these models with the observed width of the PMS locus and concluded that the width of the PMS locus is consistent with an isochronal population. My isochronal models have an intrinsic width that is similar to the width caused by an age spread of $\sim$10^6 years, so any age-spread among members of the σ Ori cluster must be *less than one million years.*

I found a significant distributed population of low-mass PMS stars in the western belt with about 240 low-mass PMS stars per square degree. Roughly half the stars are members of the 11 Myr (D$\sim$330 pc) Orion OB1a sub-association which overlaps Orion OB1b. The western belt Orion OB1b population is consistent with the 2.6×10^6 year age of the σ Ori cluster. I found no evidence that Orion OB1b population of the western belt is arranged in clusters around δ Ori and ϵ Ori.

The region around ζ Ori contains a population of low-mass PMS stars, but there is significant obscuration by interstellar matter along the line of sight. The obscuration appears to be greatest near the Orion B cloud which lies to the north and east of ζ Ori. This suggests that the young low-mass population observed near ζ Ori lies at least partially behind the Orion B cloud. I could not determine whether the low-mass population near ζ Ori is clustered around ζ Ori because the spatial distribution of low-mass PMS stars in this region is dominated by the extinction.

A copy of this this thesis is available from http://www.ess.sunysb.edu/wsherry/thesis/thesis.ps

Monte Carlo Radiative Transfer in Prestellar Cores & Protostellar Disks

Dimitris Stamatellos
Thesis work conducted at: School of Physics and Astronomy, Cardiff University, Wales, UK
Current address: School of Physics and Astronomy, Cardiff Unicersity, 5 The Parade, CF24 4EL, Cardiff, UK
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Ph.D dissertation directed by: Prof. Anthony Whitworth
Ph.D degree awarded: November 2003

We implement a Monte Carlo radiative transfer method with frequency distribution adjustment (PHAETHON) that uses a large number of monochromatic luminosity packets to represent the radiation transported through a medium. These packets are injected into the medium and interact (i.e. are absorbed and/or scattered) stochastically with it.

We use PHAETHON to study prestellar cores, represented by Bonnor-Ebert spheres, that are directly exposed to the interstellar radiation field (non-embedded cores), and cores that are embedded in molecular clouds. Our models calculate temperature profiles, SEDs and intensity profiles. We find that the temperature profiles in embedded cores are less steep than those in non-embedded cores. Deeply embedded cores (in ambient clouds with visual extinctions larger than 15-25) are almost isothermal at around 7-8 K. The temperatures inside cores in ambient molecular clouds of even moderate thickness ($A_{\rm V} \sim 5$) are less than 12 K, which is lower than what previous studies have assumed. Thus, previous mass calculations of embedded cores (e.g. in ρ Oph) based on millimetre continuum observations, may underestimate core masses by up to a factor of 2.

We also study non-spherical cores: flattened cores and cores with a "south-pole asymmetry" (the "south" region is denser than the "north" region). These models may represent more realistic density distributions than the commonly used spherically symmetric Bonnor-Ebert model. We find that SEDs of slightly asymmetric cores are essentially independent of the viewing angle. However, isophotal maps depend strongly on the viewing angle. When the core is viewed edge-on it appears elongated on mm and submm maps, which effectively trace column-density. At wavelengths near the peak of the core emission (150-250 μm), isophotal maps are strongly affected by the temperature of the core and they are not solely column density tracers. There are characteristic features on these maps which depend on the observer's viewing angle, and on the detailed density and temperature structure of the core. Hence, they contain complementary information to the mm and submm maps. The predicted characteristic features are on scales 1/5 to 1/3 of the overall core size, and high resolution observations are needed to observe them.

We extend PHAETHON to treat radiative transfer in systems with arbitrary geometries resulting from Smoothed Particle Hydrodynamics (SPH) simulations. We use the SPH tree to construct radiative transfer (RT) cells, i.e. the cells that interact with the radiation. The procedure used creates RT cells with linear size on the order of the SPH resolution. We also develop a method to treat regions close to stars, where the temperature gradients are expected to be very large. The extended version of PHAETHON can be used to perform continuum radiative transfer simulations on SPH snapshots and it is useful for comparing the results of hydrodynamic simulations with observations. We apply this method to model GM Aurigae, a T Tauri star with a circumstellar disk. We examine the case of an axisymmetric disk and the case of a non-axisymmetric, perturbed disk and find that both models are consistent with the observed SED of the system. The results indicate that PHAETHON works reasonably well for treating SPH systems with arbitrary geometries, and thus the two methods can be combined in the future in a self-consistent SPH-RT scheme.

`http://www.astro.cf.ac.uk/pub/Dimitrios.Stamatellos/phd.thesis`

New Jobs

The University of New South Wales, Sydney, Australia

Department of Astrophysics

POSTDOCTORAL RESEARCH FELLOWSHIP

in the Chemical Signatures of Massive Star Formation

Applications are invited for a Research Associate position funded by the Australian Research Council, to work with A/Prof Michael Burton on the chemical signatures of massive star formation. The position is for a person with experience in one or more of the following research areas: (i) millimetre astronomy, (ii) infrared astronomy, (iii) star formation and (iv) the ISM. Experience in modelling line emission and/or interstellar chemistry would also be an asset. The research will involve an extensive program of observational mm-wave astronomy, using principally the Mopra and Australia Telescopes. This will include conducting a major survey program with the Mopra telescope. The project will also involve close collaboration with a parallel theoretical program being undertaken at Macquarie University, led by Dr Mark Wardle.

The position will initially be for one year with the possibility of renewal for upto a further two years, subject to satisfactory performance. Candidates must possess a PhD and show a demonstrated ability to pursue independent research in the relevant fields. The salary scale for this position will be in the range set by UNSW Academic Staff Salary Rates (Level A) according to the experience of the successful applicant.

Further details can be obtained from A/Prof. Burton (email: M.Burton@unsw.edu.au; tel: +61-2-9385-5618; fax: +61-2-9385-6060; URL: www.phys.unsw.edu.au/astro). Applications should include a CV, a bibliography and a statement of research interests and plans. They should be sent to A/Prof. Burton at the School of Physics, University of New South Wales, Sydney, NSW 2052, Australia, to arrive before March 1, 2004. Applicants should also give the name and contact details (inc. emails) for three referees, who could be asked to write letters of recommendation for them.

The Department of Astrophysics at UNSW is one of Australia's leading research groups, consisting of six academics, eleven postdoctoral fellows and fifteen graduate students. We have excellent departmental computing facilities. Staff members regularly obtain time on national (AAO, ATNF, ANU 2.3m etc.), international (Gemini, ESO etc.) and space-based (e.g. HST) observing facilities. We also operate the Automated Patrol Telescope (APT) and the Mopra 22-m millimetre-wave Telescope at Siding Spring Observatory, and two automated observatories in Antarctica, at the South Pole and Dome C. We are located in Eastern Suburbs of Sydney, the Olympic city, close to both the city centre and to some wonderful beaches.

Research activities in the Department include studying galaxy clustering, cosmology, variations in fundamental constants, Antarctic astronomy, IR and MM astronomy, star formation and the interstellar medium. We have Australia's major group working in the field of star Thereormation. There are also several major instrumentation projects underway, including astronomical site-testing and infrared astronomy in Antarctica, and the development of robotic observatories. We upgraded the CSIRO Mopra telescope, which, at 22-m diameter, is now the largest millimetre-wave telescope in the Southern Hemisphere, and operate it over the winter observing season.

Postdoctoral Research Fellowships: Theory of Star Formation

Department of Physics

Macquarie University

Sydney, Australia

Applications are invited for two Research Fellow positions funded by the Australian Research Council to conduct research with Dr Mark Wardle on (i) the role of magnetic field diffusion in interstellar clouds, shock waves, gravitational collapse and protoplanetary discs; and (ii) theoretical studies of chemical signatures of massive star formation. The latter is in collaboration with with an observational program directed by Michael Burton at the University of New South Wales.

Each position may be split between the two projects, depending on the appointee's skills and interests. The positions are available on a full-time (fixed term) basis for a period of 2 years with the possibility of further appointment subject to funding and performance. Probationary conditions may apply.

The positions are available on a full-time (fixed term) basis for a period of 2 years with the possibility of further appointment subject to funding and performance. Probationary conditions may apply.

Applicants should indicate the level (A or B) at which they are applying or whether they wish to be considered for both levels.

Essential Criteria at Level A: PhD (or submitted) in a relevant area; research experience in theory and/or modelling in a relevant area.

Desirable Criteria: research experience in one or more of astrophysical magnetohydrodynamics, star formation and interstellar chemistry.

Additional Essential Criteria at Level B: At least three years postdoctoral research experience or equivalent in a relevant area; ability to carry out independent research; established publication record in a relevant area.

Salary Range: Level A (Associate Lecturer) - up to A$65,084 pa including base salary A$40,662 to A$54,997 pa, up to 17% employer's superannuation and annual leave loading. Appointees with a PhD will be appointed to a minimum of Point 6 on the salary scale, currently A$51,271 pa. Level B (Lecturer) - A$68,480 to A$81,202 pa including base salary A$57,886 to A$68,616 pa, 17% employer's superannuation and annual leave loading.

Enquiries should be directed to Dr Mark Wardle (http://wwww.physics.mq.edu.au/ wardle +61 2 9850 8909 or e-mail wardle@physics.mq.edu.au). An application package and further information can be obtained from www.ics.mq.edu.au/jobs. The selection criteria must be addressed in the application.

Applications, including full curriculum vitae, quoting the reference number 19680, visa status, and the names and addresses (including postal and/or e-mail address) of three referees should be forwarded to the Recruitment Manager, Personnel Office, Macquarie University, NSW 2109 by **1 March 2004**. Applications will not be acknowledged unless specifically requested.

Scientist - Extrasolar Planetary Research

The Laboratory for Astronomy and Solar Physics (LASP) at NASA's Goddard Space Flight Center plans to hire one or more civil servant scientists in the field of extrasolar planetary research. GSFC is now partnering with the Jet Propulsion Laboratory to investigate technologies and concepts for the Terrestrial Planet Finder (TPF) space observatory to be launched in the next decade. Several Discovery-class extrasolar planet missions are under development by scientists in LASP, including the Fourier Kelvin Stellar Interferometer (FKSI; Danchi, PI) and the Extrasolar Planet Imaging Coronagraph (EPIC; Clampin, PI). In addition, several staff members are working on innovative optical designs for high-contrast imaging. We are seeking applicants at the junior or senior level, with relevant experience in theory, data analysis, optics and/or space instrumentation. The successful applicant(s) should be engaged in a vigorous program of astronomical research, and will be expected to lead or make significant contributions to future space missions or instruments to study extrasolar planets. LASP has an exciting research environment, with significant roles in HST, WMAP, JWST, TPF and in future Einstein Probe missions. Negotiable start-up packages are available. For application instructions, please see website http://www.nasajobs.nasa.gov/ and "search jobs" for vacancy announcement number GS04B0061 beginning January 1, 2004. Address technical inquiries to Dr. Stephen Maran, Search Chair (Stephen.P.Maran@nasa.gov). The application deadline is March 31, 2004. NASA is an AA/EEO employer.

POSTDOCTORAL POSITION

PAUL SCHERRER INSTITUTE
SWITZERLAND

We invite applications for a new postdoctoral research position in stellar astrophysics, starting between spring-fall 2004. This position will be awarded for two years; extension is contingent on further funding. Candidates with an observational or theoretical background in star formation and/or magnetic activity/coronal physics in young stars are particularly encouraged to apply. Experience in either infrared, millimeter, or X-ray astronomical observing and/or related theory is welcome. Candidates with expertise in related fields of stellar astronomy are also invited to apply.

The successful candidate will work in a joint team of astronomers from the Paul Scherrer Institute and ETH Zurich. This team has a strong background and interest in X-ray, millimeter and radio astronomy of magnetically active and young stars, star formation, plasma physics, and solar physics. PSI has been involved in the development of space missions such as XMM-Newton, the James Webb Space Telescope (JWST), RHESSI, and Integral. We offer extensive scientific collaborations within several ongoing research projects. The candidate is expected to develop further vigorous research activities. Office space and computing facilities will be provided by both PSI and ETH Zurich.

Please send CV, publication list, and a short description of research interests, and arrange for two letters of recommendation sent directly to us. Applications are requested by 20 February 2004 but will continue to be considered thereafter until the position is filled. For questions, please send e-mail to Dr. M. Güdel (guedel@astro.phys.ethz.ch).

Human Resources, Ref. Code 1513
PAUL SCHERRER INSTITUT
Würenlingen and Villigen
CH-5232 Villigen PSI
Switzerland

POSTDOCTORAL FELLOWSHIPS IN STAR FORMATION

University of St Andrews, Scotland, UK

UNIVERSITY OF ST ANDREWS

SCHOOL OF PHYSICS AND ASTRONOMY

RESEARCH FELLOW

SALARY: 18,265 - 27,339 pa

The Astronomy group in the School of Physics and Astronomy at the University of St Andrews invites applications for a postdoctoral position in star formation. This 3 year post is available from 1 May 2004, or as soon as possible thereafter. We are particularly interested in candidates with experience in one or more of the following areas: star formation and feedback from young stars, stellar winds, HII regions, computational hydrodynamics and radiative transfer. You must have, or about to receive, a PhD and a demonstrated ability to pursue independent research.

Please quote ref: ME085/03

Application forms and further particulars are available from http://www.st-andrews.ac.uk/hr/ or from Human Resources, University of St Andrews, College Gate, North Street, St Andrews, Fife KY16 9AJ, (tel: 44 (0)1334 462571, by fax 44 (0)1334 462570 or by e-mail Jobline@st-andrews.ac.uk). Informal enquiries may be addressed to Ian Bonnell (iab1@st-andrews.ac.uk). Applications including curriculum vitae, publications list, statement of research achievements and interests, and letters of reference from three referees familiar with your research should arrive by the closing date: 1 March 2004.

We regret that applications cannot be made by e-mail.

The University is committed to equality of opportunity.

The Star Formation Newsletter is a vehicle for fast distribution of information of interest for astronomers working on star formation and molecular clouds. You can submit material for the following sections: *Abstracts of recently accepted papers* (only for papers sent to refereed journals, not reviews nor conference notes), *Dissertation Abstracts* (presenting abstracts of new Ph.D dissertations), *Meetings* (announcing meetings broadly of interest to the star formation and interstellar medium community), *New Books* (giving details of books relevant for the same community), *New Jobs* (advertising jobs specifically aimed towards persons within our specialty), and *Short Announcements* (where you can inform or request information from the community).

Latex macros for submitting abstracts and dissertation abstracts are appended to each issue of the newsletter.

The Star Formation Newsletter is available on the World Wide Web at http://www.ifa.hawaii.edu/~reipurth or at http://www.eso.org/gen-fac/pubs/starform/ .

New Books

Winds, Bubbles, and Explosions: A conference to honor John Dyson

Edited by Jane Arthur and William J. Henney

These are the proceedings of a conference held in Pátzcuaro, Michoacán, México in September 2002 to celebrate the 60th birthday of John Dyson. The theme of the conference reflects many of John Dyson's astrophysical interests in the interaction of young and evolved stars with their environment and the interstellar medium. The proceedings are divided into the following six sections:

I. Post-Main Sequence Winds
II. Low-Mass Stars
III. High-Mass Stars
IV. Super Novae and their Remnants
V. Large-Scale Bubbles in the ISM
VI. AGN and Starburst Winds

Among the published papers, the following are Invited Reviews:

Candidates for Ablated Flows *J. Meaburn & M.P. Redman*
Winds, Bubbles, and Outflows in Planetary Nebulae *J.A. López*
Winds, Bubbles, ...But Magnetized: Solutions for High Speed Post-AGB Winds and their Extreme Collimation *G. García-Segura, J.A. López, J. Franco*
Properties of Bipolar Planetary Nebulae *H.E. Schwarz & H. Monteiro*
Knots in Planetary Nebulae *C.R. O'Dell et al.*
An Inside-Out View of Bubbles *Y.-H. Chu, R.A. Gruendl, & M.A. Guerrero*
Stellar Outflows with New Tools: Advanced Simulations and Laboratory Experiments *A. Frank et al.*
Recent Advances in the Collapse and Fragmentation of Turbulent Molecular Cloud Cores *R.I. Klein et al.*
Generating YSO Jets: What the HST has to tell us *T.P. Ray & F. Bacciotti*
Entrainment in Herbig-Haro Objects *A.C. Raga et al.*
HH Illumination of Clumps within Molecular Clouds *D.A. Williams & S. Viti*
Photoionization and Star Formation *J. Franco*
Champagne Flows and Winds in HII Regions *S. Lizano et al.*
Large-Scale Photoevaporation Flows in HII Regions *W.J. Henney*
Ionization Front Instabilities *R.J.R. Williams*
The Partition between Terminal Speed and Mass Loss: Thin, Thick, and Rotating Line-Driven Winds *K.G. Gayley & A.J. Onifer*
X-Ray Observations of Supernova Remnants *J. Ballet*
Clouds and Instabilities in Supernova Remnant Structure: Interstellar Turbulence and Rippled Shocks *J.C. Raymond*
Planetary Nebula, Bubbles, and Superbubbles: What can we learn from their Kinematics? *M. Rosado et al.*
Large and Small Bubbles in the Messier 82 Starburst *A. Pedlar, T. Muxlow, & K.A. Wills*
Observation and Modeling of Starburst-Driven Galactic Winds *D. Breitschwerdt*
Supernova Remnant Evolution in an AGN Environment *J.M. Pittard et al.*
The Dynamical Evolution of Narrow Line Regions *M.A. Dopita et al.*
Line Formation in the Inner Starburst Regions of AGN *I. Aretxaga*

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http://www.astroscu.unam.mx/∼rmaa/rmaa.html

Meetings

Workshop on

Chondrites and the Protoplanetary Disk

November 8-11, 2004 Lihue, Kaua'i, Hawai'i

Conveners: Alexander Krot, Edward Scott, Klaus Keil, & Bo Reipurth

Session I: Chondritic meteorites, star & disk evolution
Discussion leader: A. Boss

1. Chondritic meteorites and their components
E. Scott and A. Krot

2. Early stellar evolution
B. Reipurth

3. Astrophysical observations of disk evolution around solar mass stars
L. Hartmann

4. Theoretical studies of disk evolution around solar mass stars
C. Gammie

Session II-V: Meteoritic, Experimental & Theoretical Evidence For High-Temperature Processes in the Protoplanetary Disk
Discussion leaders: H. Connolly, K. McKeegan, F. Podosek, C. Alexander

1. Chemical, mineralogical and isotopic properties of CAIs and AOAs: Clues to their origin
G. MacPherson et al.

2. Chemical, mineralogical and isotopic properties of chondrules: Clues to their origin
R. H. Jones, J. Grossman, A. Rubin

3. Petrological evidence for rapid heating and cooling during chondrule formation
J. Wasson

4. Experimental constraints on the origin of chondrules
R. Hewins, H. Connolly, L. Lofgren, and G. Libourel

5. Genetic relationship between CAIs and chondrules
S. Russell, A. Krot, G. MacPherson, G. Huss, and S. Itoh

6. Evaporation and condensation during CAI and chondrule formation
A. Davis, C. Alexander, H. Nagahara, and F. Richter

7. Origin and thermal history of FeNi-metal in primitive chondrites
A. Campbell, M. Petaev, A. Meibom, C. Perron, and B. Zanda

8. Origin of short-lived radionuclides in the solar system
J. Goswami, K. Marhas, M. Chaussidon, M. Gounelle, and B. Meyer

9. Constraints on the origin of chondrules and CAIs from short-lived and long-lived radionuclides
N. Kita, G. Huss, S. Tachibana, Y. Amelin, L. Nyquist, E. Zinner, and I. Hutcheon

10. X-ray flares and their effects on chondritic components; theory and observations
A. Glassgold, E. Feigelson and T. Montmerle

11. History of thermally processed solids in the protoplanetary disk: Reconciling theoretical and meteoritic evidence
J. Cuzzi, S. Weidenschilling, M. Petaev and E. Scott

12. Constraints on the origin of chondritic components from oxygen isotopic compositions
K. McKeegan, H. Yurimoto, R. Clayton, E. Young, and L. Leshin

13. Origin and thermal processing of dust in circumstellar and interstellar environments
X. Tielens, L. Waters, D. Hollenbach, and T. Bernatowicz

14. Nature and origin of interplanetary dust particles
L. Keller, S. Messenger, J. Bradley

15. Formation mechanisms of crystalline and amorphous material in chondrite matrices and IDPs
J. Nuth, A. Brearley, E. Scott

16. Genetic relationship between chondrules and matrix
G. Huss, C. Alexander, H. Palme, P. Bland, and J. Wasson

Sessions VI-VII. Astrophysical setting of CAI & chondrule formation
Discussion leaders: F. Shu and S. Desch

1. Thermal structures of protoplanetary disks
N. Calvet, P. D'Alessio and D. Woolum

2. Role of global and localized heating in thermal processing of solids in the protoplanetary disk
H. Palme, P. Cassen, and D. Woolum

3. Meteoritic constraints on temperatures, pressures, cooling rates, chemical compositions, and the models of condensation in the solar nebula.
Petaev M. I., Ebel D. S., and Wood J. A.

4. Role of impact and other planetary processes in the formation of chondritic components
J. Melosh, I. Sanders, P. Cassen, D. Sears, and G. Taylor

5. Shock heating: Effects on chondritic material
S. Desch, F. Ciesla, L. Hood, and T. Nakamoto

6. Shock heating: Origin of shock waves in the protoplanetary disk
A. Boss and R. Durisen

7. Jet flows: Implication for the formation and thermal processing of solids in the protoplanetary disk
F. Shu, H. Shang, and T. Lee

8. Astrophysical setting of CAI and chondrule formation
J. Wood

Editors: A. Krot, E. Scott, B. Reipurth

Associate Editors: R. Hewins, R. Jones, S. Russell, S. Desch

Other members of the organizing committee: C. Alexander, A. Boss, N. Calvet, P. Cassen, H. Connolly, J. Cuzzi, M. Gounelle, J. Grossman, L. Hartmann, K. Keil, N. Kita, G. Libourel, G. Lugmair, G. MacPherson, K. McKeegan, H. Nagahara, J. Nuth, A. Rubin, J. Wasson, B. Zanda, E. Zinner

For further information see **http://www.lpi.usra.edu/meetings/chondrites2004/**

Moving ... ??

If you move or your e-mail address changes, please send the editor your new address. If the Newsletter bounces back from an address for three consecutive months, the address is deleted from the mailing list.

IMF@50: The Initial Mass Function 50 Years Later

Jointly Organized by:
INAF–Osservatorio Astrofisico di Arcetri (Italy)
Astrophysikalisches Institut Potsdam (Germany)
http://www.arcetri.astro.it/imf50/

16-20 May 2004, Abbazia di Spineto, Siena, Italy

In July 1954, Prof. Ed Salpeter submitted a paper to the Astrophysical Journal which was to become one of the most famous astrophysics papers of the last 50 years. In this paper, entitled "The Luminosity Function and Stellar Evolution", he introduced the terms "original mass function" and "original luminosity function", and estimated the probability for the creation of stars of given mass at a particular time, now known as the "Salpeter Initial Mass Function", or IMF. The paper was written at the Australian National University in Canberra on leave of absence from Cornell University (USA) and was published as 7 page note in the Astrophysical Journal in 1955.

To celebrate the 50th anniversary of the IMF, along with Ed Salpeter's 80th birthday, we intend to organize a special meeting that will bring together scientists involved in the empirical determination of this fundamental quantity in a variety of astrophysical contexts and others fascinated by the deep implications of the IMF on star formation theories, on the physical conditions of the gas before and after star formation, and on galactic evolution and cosmology.

The Scientific Programme will include the following topics:

Stars and the IMF: the IMF in star forming regions and the galactic disc; the lower and upper end of the IMF in the Galaxy and elsewhere.

Gas and the IMF: origin and structure of molecular clouds, the initial conditions for the IMF, turbulence and magnetic fields; the HI/H_2 connection, cold clumps, the reservoir for future star formation, from HI to HII.

The IMF in Extreme Environments: from local dwarfs and spirals to starbursts and mergers, universality and dependences; the first stars.

The IMF@50 Conference will take place from May 16–20, 2004 in The Abbazia di Spineto, Siena-Italy, one of the most beautiful spots of the Tuscan countryside. Attendance will be limited to about 90 partecipants, the maximum capacity of the Abbey facilities.

REGISTRATION: The registration deadline is **February 15, 2004**. Due to the large number of confirmed Invited Speakers and to the limited overall number of partecipants, confirmation of attendence is subject to the decision of the OC. The response will be sent via e-mail to all applicants within 3 weeks of reception of the Registration Form.

SCIENTIFIC CONTRIBUTIONS: In addition to the Invited Speakers, there will be time for a limited number of oral contributions. There is no limitation to the number and size of Posters that can presented at the Conference. Oral contributions will be selected by the organizers on the basis of early registration, balance of the topics in the programme, and personal collaboration with Ed Salpeter.

ORGANIZING COMMITTEE: E. Corbelli and F. Palla (INAF-Arcetri), F. Pacini (University of Firenze), H. Zinnecker (AIP, Potsdam)

CONTACTS: For further inquiries concerning travel, accomodation, and other logistic details, contact us at:
edvige@arcetri.astro.it, palla@arcetri.astro.it

THE YOUNG LOCAL UNIVERSE

La Thuile, Aosta Valley, Italy, March 21 - 28, 2004

Local Organizing Committee: T. Montmerle (Chair), J. Bouvier, A. Chalabaev, B. Lefloch (LAOG, Grenoble); R. Neri (IRAM); D. Elbaz, M. Sauvage (CEA/DAPNIA/SAp, Saclay); J. Tran Thanh Van (LPT, Orsay)

Scientific Advisory Committee: J. Alves (ESO), Ph. Andr (Saclay), D. Breitschwerdt (Vienna), C. Cesarsky (ESO), F. Combes (Paris), Y. Fukui (Kyoto), T. Heckman (Baltimore), T. Henning (Heidelberg), V. Icke (Leiden), J. Kndlseder (Toulouse), D. Kunth (Paris), A. Maeder (Geneva), F. Palla (Florence), M. Tagger (Saclay), H. Zinnecker (Potsdam).

Web page: http://www-laog.obs.ujf-grenoble.fr/ylu/

Deadline for Hotel reservations and Abstracts: Feb. 15, 2004

The main goal of this meeting is to bring together researchers and students working on the "Young Local Universe", i.e. on the ISM and star formation from our Galaxy to nearby galaxies as far as molecular clouds and star-forming regions can be resolved by modern ground-based and space observatories. The main effort will be devoted to bring together in an "integrated" fashion participants from galactic and extragalactic backgrounds.

As a preliminary approach, the discussion will include galactic features such as the Gould Belt, the so-called Local Bubble and galactic HI bubbles, giant HII regions and galactic starburst-like regions of massive star formation, the Local Group (LMC, SMC, etc.), extragalactic bubbles, colliding galaxies and mergers (Antennae, etc.). The corresponding distances span a range of roughly six orders of magnitude, from 50 pc to 10-20 Mpc.

Theoretical issues among the following ones will also be covered: cloud core collapse, spiral structure, dynamics of central regions of galaxies, the role of metallicity and nucleosynthetic evolution, feedback effects from massive stars (winds, supernovae), interstellar turbulence and magnetic fields, irradiation effects by high-energy particles, triggered star formation, etc.

Future prospects include high-angular resolution and/or large instruments (adaptive optics, interferometers like ALMA and the VLTI, ELTs, space missions like JWST) and/or high spectral resolution instruments like Herschel, or XEUS, all approved or projected for the next decade. The first results expected from the ultra-violet and mid- to far-infrared space observatories GALEX and SIRTF will be highlighted.

It is anticipated that the program will be organized as follows. Each day or half-day will cover a single topic, starting with a review by a senior expert. The topic will be selected in such a way that galactic and extragalactic issues are discussed together (example: the IMF). Then shorter talks will be given, including invited papers and contributed papers selected by the Program Committee. Younger researchers are encouraged to submit papers. Ample time will be reserved for discussions. In particular, in the traditional framework of the Moriond meetings, most of the afternoon will be free each day, amply allowing for contacts either on the premises or somewhere on the mountains...

Short Announcements

The proceedings of IAU Symposium No. 221 on "Star Formation at High Angular Resolution" are now completed, and are available at **http://www.phys.unsw.edu.au/iau221** for a limited period until the publisher has the book ready.