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Abstracts of recently accepted papers

Neptune's capture of its moon Triton in a binary–planet gravitational encounter

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Triton is Neptune's principal satellite and is by far the largest retrograde satellite in the Solar System (its mass is ~ 40 per cent greater than that of Pluto). Its inclined and circular orbit lies between a group of small inner prograde satellites and a number of exterior irregular satellites with both prograde and retrograde orbits. This unusual configuration has led to the belief that Triton originally orbited the Sun before being captured in orbit around Neptune. Existing models for its capture, however, all have significant bottlenecks that make their effectiveness doubtful. Here we report that a three-body gravitational encounter between a binary system (of $\sim 10^3$-kilometre-sized bodies) and Neptune is a far more likely explanation for Triton's capture. Our model predicts that Triton was once a member of a binary with a range of plausible characteristics, including ones similar to the Pluto–Charon pair.

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The Evolution of Outflow-Envelope Interactions in Low-Mass Protostars

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We present multi-line and continuum observations of the circumstellar environment within 10^4 AU of a sample of protostars to investigate how the effects of outflows on their immediate environment changes over time. CO(1-0) emission probes the high-velocity molecular outflows near the protostars and demonstrate that the outflow opening angle widens as the nascent star evolves. Maps of the ^{13}CO(1-0) and HCO$^+$(1-0) outflow emission show that protostellar winds erode the circumstellar envelope through the entrainment of the outer envelope gas. The spatial and velocity distribution of the dense circumstellar envelope, as well as its mass, is traced by the C^{18}O(1-0) emission and also displays evolutionary changes. We show that outflows are largely responsible for these changes, and propose an empirical model for the evolution of outflow-envelope interactions. In addition, some of the outflows in our sample appear to affect the chemical composition of the surrounding environment, enhancing the HCO$^+$ abundance. Overall, our results confirm that outflows play a major role in the star formation process through their strong physical and chemical impacts on the environments of the young protostars.

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http://www.astro.caltech.edu/~harce/papers/
http://arxiv.org/abs/astro-ph/0605139

Hydrodynamics of Cometary Compact HII Regions

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We present numerical radiation-hydrodynamic H II regions for a number of champagne flow and bowshock models. For the champagne flow models we study smooth density distributions with both steep and shallow gradients. We also consider cases where the ionizing star has a strong stellar wind, and cases in which the star additionally has a proper motion within the ambient density gradient. We find that our champagne flow plus stellar wind models have limb-brightened morphologies and kinematics which can see the line-of-sight velocities change sign twice between the head and tail of the cometary H II region, with respect to the rest frame velocity. Our bowshock models show that pressure gradients across and within the shell are very important for the dynamics, and that simple analytic models assuming thin shells in ram pressure balance are wholly inadequate for describing the shape and kinematics of these objects at early times in their evolution. The dynamics of the gas behind the shock in the neutral material ahead of the ionization front in both champagne flow and bowshock type cometary H II regions is also discussed. We present simulated emission-measure maps and long-slit spectra of our results. Our numerical models are not tailored to any particular object but comparison with observations from the literature shows that, in particular, the models combining density gradients and stellar winds are able to account for both the morphology and general radial velocity behavior of several observed cometary H II regions, such as the well-studied object G29.96−0.02.

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The 1966–1967 Outburst of V1647 Orionis and the Appearance of McNeil's Nebula

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We present the results of an investigation aimed at characterizing previous eruptions of V1647 Orionis, the illuminating star of McNeil's Nebula. Photographic plates and films from the Asiago Observatory (1960–1998) and Harvard Observatory (1898–1974) collections were inspected for the nebula. We have determined that, to the plate limits, the known eruption of 1966–1967 is the only one detected during the 38 year period covered by the Asiago archive. In the Harvard collection, we did not find any additional occurrences in approximately 400 plates of the region taken over the last 100 years. Based on the Asiago material we here present a study of the 1966–1967 event. McNeil's Nebula and V1647 Ori are clearly visible on 19 plates obtained with the Asiago 67/92 cm Schmidt telescope from October 22, 1966 to March 4, 1967. The object is not seen on plates taken in March 1966 nor in November 1967, thus setting a minimum duration time for the eruptive event of 5 months, and a maximum of 20 months. The 19 plates showing McNeil's Nebula were digitized and a morphological and photometric analysis of the object was undertaken. These data show temporal photometric variability as well as structural differences between different color bands. We finally compare the 1966–1967 event to the recent 2003–2006 eruption and consider the nature of V1647 Ori within the framework of EXor and FUor eruptions.

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http://ftp.gemini.edu/staff/caa/asiago.pdf

CaII Infrared triplet line models in Classical T Tauri stars

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We study the formation of the Calcium II infrared triplet lines 8498Å, 8542Å and 8662Å, in the accreting magnetospheric flows of Classical T Tauri stars (CTTS), and present a grid of models for a large range of magnetospheric conditions. We apply our models to the interpretation of multi epoch observations of the CTTS DI Cep. We find that these lines form in the magnetospheric infall and that the variability of the CaII triplet lines in DI Cep can be explained in the context of changes in the mass accretion rate/temperature of the accretion column gas.

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http://www.astro.up.pt/investigacao/ficheiros/174.pdf

The evolutionary state of the southern dense core Cha-MMS1

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Aims. Our goal is to set constraints on the evolutionary state of the dense core Cha-MMS1 in the Chamaeleon I molecular cloud.
Methods. We analyze molecular line observations carried out with the new submillimeter telescope APEX. We look for outflow signatures around the dense core and probe its chemical structure, which we compare to predictions of models of gas-phase chemistry. We also use the public database of the Spitzer Space Telescope (SST) to compare Cha-MMS1 with the two Class 0 protostars IRAM 04191 and L1521F, which are at the same distance.
Results. We measure a large deuterium fractionation for N_2H^+ ($11 \pm 3\%$), intermediate between the prestellar core L1544 and the very young Class 0 protostar L1521F. It is larger than for HCO^+ ($2.5 \pm 0.9\%$), which is probably the result of depletion removing HCO^+ from the high-density inner region. Our CO(3-2) map reveals the presence of a bipolar outflow driven by the Class I protostar Ced 110 IRS 4 but we do not find evidence for an outflow powered by Cha-MMS1. We also report the detection of Cha-MMS1 at 24, 70 and 160 μm by the instrument MIPS of the SST, at a level nearly an order of magnitude lower than IRAM 04191 and L1521F.
Conclusions Cha-MMS1 appears to have already formed a compact object, either the first hydrostatic core at the very end of the prestellar phase, or an extremely young protostar that has not yet powered any outflow, at the very beginning of the Class 0 accretion phase.

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VLT K-band spectroscopy of massive young stellar objects in (ultra-)compact HII regions

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High-quality K-band spectra of strongly reddened point sources, deeply embedded in (ultra-) compact HII regions, have revealed a population of 20 young massive stars showing no photospheric absorption lines, but sometimes strong Brγ emission. The Brγ equivalent widths occupy a wide range (from about 1 to over 100 Å); the line widths of 100–200 km s^{-1} indicate a circumstellar rather than a nebular origin. The K-band spectra exhibit one or more features commonly associated with massive young stellar objects (YSOs) surrounded by circumstellar material: a very red colour $(J-K) > 2$, CO bandhead emission, hydrogen emission lines (sometimes doubly peaked), and FeII and/or MgII emission lines. The large number of objects in our sample allows a more detailed definition and thorough investigation of the properties of the massive YSOs. In the $(K, J-K)$ colour-magnitude diagram (CMD) the massive YSO candidates are located in a region delimited by the OB zero-age main sequence, Be stars, Herbig Ae and Be stars, and B[e] supergiants. The massive YSO distribution in the CMD suggests that the majority of the objects are of similar spectral type as the Herbig Be stars, but some of them are young O stars. The spectral properties of the observed objects do not correlate with the location in the CMD. The CO emission must come from a relatively dense ($\sim 10^{10}$cm^{-3}) and hot ($T \sim 2000-5000$ K) region, sufficiently shielded from the intense UV radiation field of the young massive star. The hydrogen emission is produced in an ionised medium exposed to UV radiation. The best geometrical solution is a dense and neutral circumstellar disk causing the CO bandhead emission, and an ionised upper layer where the hydrogen lines are produced. We present arguments that the circumstellar disk is more likely a remnant of the accretion process than the result of rapid rotation and mass loss such as in Be/B[e] stars.

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A Remnant Disk around a Young Massive Star

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While the formation of low-mass stars has become a well-studied process, it is still difficult to verify a similar evolutionary sequence for massive stars. Although several young stages from massive starless cores to massive protostellar candidates with jets and outflows have been observed, massive star/disk systems whose properties can be inferred uniquely are rare. The final stage of this sequence, i.e. a new-born massive star which is still surrounded by a remnant disk, is missing. This is probably a consequence of the rapid evolution of these systems and the early destruction of the disk in the vicinity of a massive star. We report on an optically visible young massive star (IRS 15) within M17 that displays a huge IR-excess. This fortunate coincidence offers the rare opportunity to investigate the star as well as its circumstellar environment in great detail. We have performed both optical and infrared photometry and spectroscopy of the stellar source; additionally, its circumstellar environment has been investigated by mid-infrared imaging. Our data suggest that IRS 15 is a star of about 26 $M_\odot$ surrounded by a huge remnant disk of about half a Jupiter mass of dust. From this we corroborate that massive stars can form by disk accretion and conclude that also their circumstellar disks evolve like those of low-mass stars.

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Chondrule formation in particle-rich nebular regions at least hundreds of kilometres across

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Chondrules are millimetre-sized spherules (mostly silicate) that dominate the texture of primitive meteorites. Their formation mechanism is debated, but their sheer abundance suggests that the mechanism was both energetic and ubiquitous in the early inner Solar System. The processes suggested—such as shock waves, solar flares or nebula lightning—operate on different length scales that have been hard to relate directly to chondrule properties. Chondrules are depleted in volatile elements, but surprisingly they show little evidence for the associated loss of lighter isotopes one would expect. Here we report a model in which molten chondrules come to equilibrium with the gas that was evaporated from other chondrules, and which explains the observations in a natural way. The regions within which the chondrules formed must have been larger than 150–6,000 km in radius, and must have had a precursor number density of at least 10 m^{-3}. These constraints probably exclude nebula lightning, and also make formation far from the nebula midplane problematic. The wide range of chondrule compositions may be the result of different combinations of the local concentrations of precursors and the local abundance of water ice or vapour.

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The fractal dimensions of the spatial distribution of young open clusters in the solar neighbourhood

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Context. Fractals are geometric objects with dimensionalities that are not integers. They play a fundamental role in the dynamics of chaotic systems. Observation of fractal structure in both the gas and the star-forming sites in galaxies suggests that the spatial distribution of young open clusters should follow a fractal pattern, too.

Aims. Here we investigate the fractal pattern of the distribution of young open clusters in the Solar Neighbourhood using a volume-limited sample from WEBDA and a multifractal analysis. By counting the number of objects inside spheres of different radii centred on clusters, we study the homogeneity of the distribution.

Methods. The fractal dimension D of the spatial distribution of a volume-limited sample of young open clusters is determined by analysing different moments of the count-in-cells. The spectrum of the Minkowski-Bouligand dimension of the distribution is studied as a function of the parameter q. The sample is corrected for dynamical effects.

Results. The Minkowski-Bouligand dimension varies with q in the range 0.71–1.77, therefore the distribution of young open clusters is fractal. We estimate that the average value of the fractal dimension is $\langle D \rangle = 1.7 \pm 0.2$ for the distribution of young open clusters studied.

Conclusions. The spatial distribution of young open clusters in the Solar Neighbourhood exhibits multifractal structure. The fractal dimension is time-dependent, increasing over time. The values found are consistent with the fractal dimension of star-forming sites in other spiral galaxies.

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A comparative study of disc-planet interaction

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We perform numerical simulations of a disc-planet system using various grid-based and smoothed particle hydrodynamics (SPH) codes. The tests are run for a simple setup where Jupiter and Neptune mass planets on a circular orbit open a gap in a protoplanetary disc during a few hundred orbital periods. We compare the surface density contours, potential vorticity and smoothed radial profiles at several times. The disc mass and gravitational torque time evolution are analyzed with high temporal resolution. There is overall consistency between the codes. The density profiles agree within about 5% for the Eulerian simulations while the SPH results predict the correct shape of the gap although have less resolution in the low density regions and weaker planetary wakes. The disc masses after 200 orbital periods agree within 10%. The spread is larger in the tidal torques acting on the planet which agree within a factor 2 at the end of the simulation. In the Neptune case the dispersion in the torques is greater than for Jupiter, possibly owing to the contribution from the not completely cleared region close to the planet.

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Astrochemical confirmation of the rapid evolution of massive YSOs and explanation for the inferred ages of hot cores

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Aims: To understand the roles of infall and protostellar evolution on the envelopes of massive young stellar objects (YSOs).

Methods: The chemical evolution of gas and dust is traced, including infall and realistic source evolution. The temperatures are determined self-consistently. Both ad/desorption of ices using recent laboratory temperature-programmed-desorption measurements are included.

Results: The observed water abundance jump near 100 K is reproduced by an evaporation front which moves outward as the luminosity increases. Ion-molecule reactions produce water below 100 K. The age of the source is constrained to $t \sim 8 \pm 4 \times 10^4$ yrs since YSO formation. It is shown that the chemical age-dating of hot cores at $\sim$ few $\times\, 10^3 - 10^4$ yr and the disappearance of hot cores on a timescale of $\sim 10^5$ yr is a natural consequence of infall in a dynamic envelope and protostellar evolution. Dynamical structures of $\sim$ 350AU such as disks should contain most of the complex second generation species. The assumed order of desorption kinetics does not affect these results.

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Accretion in protoplanetary disks: the imprint of core properties

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In this Letter we present a theoretical scenario to explain the steep correlation between disk accretion rates and stellar masses observed in pre-main sequence stars. We show that the correlations and spread observed in the two best studied regions, ρ-Ophiuchus and Taurus, can be reproduced by a simple model of single star formation from a rotating collapsing core and the viscous evolution of the circumstellar disk. In this model, the rate of rotation of the parent core sets the value of the 'centrifugal radius' within which the infalling matter is loaded onto the surface of the disk. As a consequence, the disk accretion rate measured long after the dispersal of the parental core bears the imprint of the initial conditions of star formation. The observed trend results naturally if, at the onset of the collapse, cores of all masses rotate with the same distribution of angular velocities measured in units of the break-up rotation rate.

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The distribution of ND_2H in LDN1689N

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Finding tracers of the innermost regions of prestellar cores is important for understanding their chemical and dynamical evolution before the onset of gravitational collapse. While classical molecular tracers, such as CO and CS, have been shown to be strongly depleted in cold, dense gas by condensation on grain mantles, it has been a subject of discussion to what extent nitrogen-bearing species, such as ammonia, are affected by this process. As deuterium fractionation is efficient in cold, dense gas, deuterated species are excellent tracers of prestellar cores. A comparison of the spatial distribution of neutral and ionized deuterated species with the dust continuum emission can thus provide important insights into the physical and chemical structure of such regions.

We study the spatial distribution of the ground-state 335.5 GHz line of ND_2H in LDN1689N, using APEX, and compare it with the distribution of the DCO^+(3–2) line, as well as the 350 μm dust continuum emission observed with the SHARC II bolometer camera at CSO.

While the distribution of the ND_2H emission in LDN1689N is generally similar to that of the 350 μm dust continuum emission, the peak of the ND_2H emission is offset by $\sim 10''$ to the East from the dust continuum and DCO^+ emission peak. ND_2H and ND_3 share the same spatial distribution. The observed offset between the ND_2H and DCO^+ emission is consistent with the hypothesis that the deuterium peak in LDN1689N is an interaction region between the outflow shock from IRAS16293–2422 and the dense ambient gas. We detect the $J = 4 \rightarrow 3$ line of $H^{13}CO^+$ at 346.998 GHz in the image side band serendipitously. This line shows the same spatial distribution as DCO^+(3–2), and peaks close to the 350 μm emission maximum which provides further support for the shock interaction scenario.

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Seeing Star Formation Regions with Gravitational Microlensing

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We qualitatively study the effects of gravitational microlensing on our view of unresolved extragalactic star formation regions. Using a general gravitational microlensing configuration, we perform a number of simulations that reveal that specific imprints of the star-forming region are imprinted, both photometrically and spectroscopically, on observations. Such observations have the potential to reveal the nature and size of these star-forming regions through the degree of variability observed in a monitoring campaign and hence resolve the star formation regions in distant galaxies that are too small to be probed via more standard techniques.

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Production of the Extended Scattered Disk by Rogue Planets

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We show that if the early outer solar system contained one or more additional planets of an Earth mass or larger, these planets are likely to be temporarily emplaced in the Kuiper Belt's "scattered disk." While on an orbit of large semimajor axis, such a "rogue planet" may efficiently raise either (1) the perihelia of other scattered-disk objects, emplacing them in the "extended scattered disk," or (2) their orbital inclinations, to the levels currently observed in the Kuiper Belt. With even a single rogue planet present, the probability of producing extended scattered disk objects is 20%–50%. After the rogue is removed from the system (on a characteristic timescale of 200 Myr), most extended scattered disk orbits are not appreciably modified over the age of the solar system. Objects with large orbital inclinations like the outliers 2004 XR_{190}, 2003 UB_{313}, 2000 CR_{105}, and Sedna are also produced.

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Low sulfur depletion in the Horsehead PDR

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We present $3.65'' \times 3.34''$ angular–resolution IRAM *Plateau de Bure Interferometer* observations of the CS J=2–1 line toward the Horsehead *Photodissociation Region* (PDR), complemented with IRAM–30m single–dish observations of several rotational lines of CS, $C^{34}S$ and HCS^+. We analyse the CS and HCS^+ photochemistry, excitation and radiative transfer to obtain their abundances and the physical conditions prevailing in the cloud edge. Since the CS abundance scales to that of sulfur, we determine the gas phase sulfur abundance in the PDR, an interesting intermediate medium between translucent clouds (where sulfur remains in the gas phase) and dark clouds (where large depletions have been invoked). A nonlocal non–LTE radiative transfer code including dust and cosmic background illumination adapted to the Horsehead geometry has been developed to carefuly analyse the CS, $C^{34}S$, HCS^+ and $C^{18}O$ rotational line emission. We use this model to consistently link the line observations with photochemical models to determine the CS/HCS^+/S/S^+ structure of the PDR. Densities of $n(H_2) \simeq (0.5 - 1.0)\times10^5$ cm^{-3} are required to reproduce the CS and $C^{34}S$ J=2–1 and 3–2 line emission. CS J=5–4 lines show narrower line widths than the CS low–J lines and require higher density gas components not resolved by the $\sim10''$ IRAM–30m beam. These values are larger than previous estimates based in CO observations. We found $\chi(CS)$=$(7\pm3)\times10^{-9}$ and $\chi(HCS^+)$=$(4\pm2)\times10^{-11}$ as the averaged abundances in the PDR. According to photochemical models, the gas phase sulfur abundance required to reproduce these values is S/H=$(3.5\pm1.5)\times10^{-6}$, only a factor $<$4 less abundant than the solar sulfur elemental abundance. Since only lower limits to the gas temperature are constrained, even lower sulfur depletion values are possible if the gas is significantly warmer. The combination of CS, $C^{34}S$ and HCS^+ observations together with the inclusion of the most recent CS collisional and chemical rates in our models implies that sulfur depletion invoked to account for CS and HCS^+ abundances is much smaller than in previous studies.

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Hubble Space Telescope ACS Multiband Coronagraphic Imaging of the Debris Disk around β Pictoris

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We present F435W (B), F606W (broad V), and F814W (broad I) coronagraphic images of the debris disk around β Pictoris obtained with the *Hubble Space Telescope*'s Advanced Camera for Surveys. These images provide the most photometrically accurate and morphologically detailed views of the disk between 30 and 300 AU from the star ever recorded in scattered light. We confirm that the previously reported warp in the inner disk is a distinct secondary disk inclined by $\sim 5°$ from the main disk. The projected spine of the secondary disk coincides with the isophotal inflections, or "butterfly asymmetry," previously seen at large distances from the star. We also confirm that the opposing extensions of the main disk have different position angles, but we find that this "wing-tilt asymmetry" is centered on the star rather than offset from it, as previously reported. The main disk's northeast extension is linear from 80 to 250 AU, but the southwest extension is distinctly bowed with an amplitude of ~ 1 AU over the same region. Both extensions of the secondary disk appear linear, but not collinear, from 80 to 150 AU. Within ~ 120 AU of the star, the main disk is $\sim 50\%$ thinner than previously reported. The surface brightness profiles along the spine of the main disk are fitted with four distinct radial power laws between 40 and 250 AU, while those of the secondary disk between 80 and 150 AU are fitted with single power laws. These discrepancies suggest that the two disks have different grain compositions or size distributions. The F606W/F435W and F814W/F435W flux ratios of the composite disk are nonuniform and asymmetric about both projected axes of the disk. The disk's northwest region appears 20%–30% redder than its southeast region, which is inconsistent with the notion that forward scattering from the nearer northwest side of the disk should diminish with increasing wavelength. Within ~ 120 AU, the $m_{\rm F435W} - m_{\rm F606W}$ and $m_{\rm F435W} - m_{\rm F814W}$ colors along the spine of the main disk are $\sim 10\%$ and $\sim 20\%$ redder, respectively, than those of β Pic. These colors increasingly redden beyond ~ 120 AU, becoming 25% and 40% redder, respectively, than the star at 250

AU. These measurements overrule previous determinations that the disk is composed of neutrally scattering grains. The change in color gradient at $\sim$ 120 AU nearly coincides with the prominent inflection in the surface brightness profile at $\sim$ 115 AU and the expected water-ice sublimation boundary. We compare the observed red colors within $\sim$ 120 AU with the simulated colors of nonicy grains having a radial number density $\propto r^{-3}$ and different compositions, porosities, and minimum grain sizes. The observed colors are consistent with those of compact or moderately porous grains of astronomical silicate and/or graphite with sizes $\geq 0.15 - 0.20\mu$m, but the colors are inconsistent with the blue colors expected from grains with porosities $\geq 90\%$. The increasingly red colors beyond the ice sublimation zone may indicate the condensation of icy mantles on the refractory grains, or they may reflect an increasing minimum grain size caused by the cessation of cometary activity.

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A sensitive survey for water maser emission towards Bok globules using the Robledo 70m antenna

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We report the most sensitive water maser survey towards Bok globules to date, using NASA's 70m antenna in Robledo de Chavela (Spain). We observed 207 positions within the Clemens & Barvainis (1988) catalog with a higher probability of harboring a young star, using as selection criteria the presence of radio continuum emission (from submillimeter to centimeter wavelengths), geometrical centers of molecular outflows, peaks in maps of high-density gas tracers (NH_3 or CS), and IRAS point sources. We have obtained 7 maser detections, 6 of which (in CB 34, CB 54, CB 65, CB 101, CB 199, and CB 232) are reported for the first time here. Most of the water masers we detected are likely to be associated with young stellar objects (YSOs), except for CB 101 (probably an evolved object) and CB 65 (uncertain nature). The water maser in CB 199 shows a relatively high shift ($\simeq$ 30 km s^{-1}) of its velocity centroid with respect to the cloud velocity, which is unusual for low-mass YSOs. We speculate that high-velocity masers in this kind of object could be related with episodes of energetic mass-loss in close binaries. Alternatively, the maser in CB 199 could be pumped by a protoplanetary or a young planetary nebula. CB 232 is the smallest Bok globule ($\simeq$ 0.6 pc) known to be associated with water maser emission, although it would be superseded by the cases of CB 65 ($\simeq$ 0.3 pc) and CB 199 ($\simeq$ 0.5 pc) if their association with YSOs is confirmed. All our selection criteria have statistically compatible detection rates, except for IRAS sources, which tend to be a somewhat worse predictor for the presence of maser emission.

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Star formation in molecular cores – III. The effect of the turbulent power spectrum

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We investigate the effect of the turbulent power spectrum ($P(k) \propto k^{-n}$, with $n = 3$, 4, or 5) on the fragmentation of low-mass cores, by means of SPH simulations. We adopt initial density profiles and low levels of turbulence based on observation, and for each n-value we conduct an ensemble of simulations with different initial seeds for the turbulent velocity field, so as to obtain reasonable statistics. We find that when power is concentrated at larger scales (i.e. for larger n), more protostellar objects form and there is a higher proportion of low-mass stars and brown dwarfs. This is in direct contrast with the recent results of Delgado Donate et al., presumably because they adopted much higher levels of turbulence.

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Spitzer-IRS Observations of FU Orionis Objects

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We present 5-35 μm spectra, taken with the Infrared Spectrograph (IRS) on the Spitzer Space Telescope, of five FU Orionis objects: FU Ori, V1515 Cyg, V1057 Cyg, BBW 76, and V346 Nor. All but V346 Nor reveal amorphous silicate grains in emission at 10 μm and 20 μm, and show water-vapor absorption bands at 5.8 and 6.8 μm and SiO or possibly methane absorption at 8 μm. These absorption features closely match these bands in model stellar photospheres — signs of the gaseous photospheres of the inner regions of these objects' accretion disks. The continuum emission at 5-8 μm is also consistent with such disks, and, for FU Orionis and BBW 76, longer-wavelength emission may be fit by a model which includes moderate disk flaring. V1057 Cyg and V1515 Cyg have much more emission at longer wavelengths than the others, perhaps evidence of substantial remnant of their natal, infalling envelopes.

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$C^{18}O$ (3–2) observations of the Cometary Globule CG 12: A cold core and a $C^{18}O$ hot spot

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The feasibility of observing the $C^{18}O$ (3–2) spectral line in cold clouds with the APEX telescope has been tested. As the line at 329.330 GHz lies in the wing of a strong atmospheric H_2O absorption it can be observed only at high altitude observatories. Using the three lowest rotational levels instead of only two helps to narrow down the physical properties of dark clouds and globules. The centres of two $C^{18}O$ maxima in the high latitude low mass star forming region CG 12 were mapped in $C^{18}O$ (3–2) and the data were analyzed together with spectral line data from the SEST. The T_{MB} (3–2)/T_{MB} (2–1) ratio in the northern $C^{18}O$ maximum, CG 12 N, is 0.8, and in the southern maximum, CG 12 S, ∼2. CG 12 N is modelled as a 120" diameter (0.4pc) cold core with a mass of 27 $M_\odot$. A small size maximum with a narrow, 0.8 kms^{-1}, $C^{18}O$ (3–2) spectral line with a peak temperature of $T_{MB} \sim 11$ K was detected in CG 12 S. This maximum is modelled as a 60"-80" diameter (∼0.2pc) hot (80 K< Tex < 200 K) ∼1.6 $M_\odot$ clump. The source lies on the axis of a highly collimated bipolar molecular outflow near its driving source. This is the first detection of such a compact, warm object in a low mass star forming region.

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Detection of H_2D^+ in a massive prestellar core in Orion B

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Aims. The purpose of this study is to examine the prediction that the deuterated H_3^+ ion, H_2D^+, can be found exclusively in the coldest regions of molecular cloud cores. This is also a feasibility study for the detection of the ground-state line of ortho-H_2D^+ at 372 GHz with APEX.

Methods. The 1(10)-1(11) transition of H_2D^+ at 372 GHz was searched towards selected positions in the massive star forming cloud OriB9, in the dark cloud L183, and in the low- to intermediate mass star-forming cloud R CrA.

Results. The line was detected in cold, prestellar cores in the regions of OriB9 and L183, but only upper limits were obtained towards other locations which either have elevated temperatures or contain a newly born star. The H_2D^+ detection towards OriB9 is the first one in a massive star-forming region. The fractional ortho-H_2D^+ abundances (relative to H_2) are estimated to be $\sim 1\,10^{-10}$ in two cold cores in OriB9, and $3\,10^{-10}$ in the cold core of L183.

Conclusions. The H_2D^+ detection in OriB9 shows that also massive star forming regions contain very cold prestellar cores which probably have reached matured chemical composition characterized, e.g., by a high degree of deuterium fractionation. Besides as a tracer of the interior parts of prestellar cores, H_2D^+ may therefore be used to put contraints on the timescales related to massive star formation.

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Why do T Tauri disks accrete?

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Observations of T Tauri stars and young brown dwarfs suggest that the accretion rates of their disks scale strongly with the central stellar mass, approximately $\dot{M} \propto M_*^2$. No dependence of accretion rate on stellar mass is predicted by the simplest version of the layered disk model of Gammie (1996), in which non-thermal ionization of upper disk layers allows accretion to occur via the magnetorotational instability. We show that a minor modification of Gammie's model to include heating by irradiation from the central star yields a modest dependence of $\dot{M}$ upon the mass of the central star. A purely viscous disk model could provide a strong dependence of accretion rate on stellar mass if the initial disk radius (before much viscous evolution has occurred) has a strong dependence on stellar mass. However, it is far from clear that at least the most massive pre-main sequence disks can be totally magnetically activated by X-rays or cosmic rays. We suggest that a combination of effects are responsible for the observed dependence, with the lowest-mass stars having the lowest mass disks, which can be thoroughly magnetically active, while the higher-mass stars have higher mass disks which have layered accretion and relatively inactive or "dead" central zones at some radii. In such dead zones, we suggest that gravitational instabilities may play a role in allowing accretion to proceed. In this connection, we emphasize the uncertainty in disk masses derived from dust emission, and argue that T Tauri disk masses have been systematically underestimated by conventional analyses. Further study of accretion rates, especially in the lowest-mass stars, would help to clarify the mechanisms of accretion in T Tauri stars.

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The Birth of Molecular Clouds: Formation of Atomic Precursors in Colliding Flows

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Molecular Cloud Complexes (MCCs) are highly structured and "turbulent". Observational evidence suggests that MCCs are dynamically dominated systems, rather than quasi-equilibrium entities. The observed structure is more likely a consequence of the formation process rather than something that is imprinted after the formation of the MCC. Converging flows provide a natural mechanism to generate MCC structure. We present a detailed numerical analysis of this scenario. Our study addresses the evolution of a MCC from its birth in colliding atomic hydrogen flows up until

the point when H_2 may begin to form. A combination of dynamical and thermal instabilities breaks up coherent flows efficiently, seeding the small-scale non-linear density perturbations necessary for local gravitational collapse and thus allowing (close to) instantaneous star formation. Many observed properties of MCCs come as a natural consequence of this formation scenario. Since converging flows are omnipresent in the ISM, we discuss the general applicability of this mechanism, from local star formation regions to galaxy mergers.

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Turbulent Gas Flows in the Rosette and G216-2.5 Molecular Clouds: Assessing Turbulent Fragmentation Descriptions of Star Formation

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The role of turbulent fragmentation in regulating the efficiency of star formation in interstellar clouds is examined from new wide-field imaging of ^{12}CO and ^{13}CO $J = 1 - 0$ emission from the Rosette and G216-2.5 molecular clouds. The Rosette molecular cloud is a typical star-forming giant molecular cloud, and G215-2.5 is a massive molecular cloud with no OB stars and very little low-mass star formation. The properties of the turbulent gas flow are derived from the set of eigenvectors and eigenimages generated by principal component analysis (PCA) of the spectroscopic data cubes. While the two clouds represent quite divergent states of star formation activity, the velocity structure functions for both clouds are similar. The sonic scale, λ_S, defined as the spatial scale at which turbulent velocity fluctuations are equivalent to the local sound speed, and the turbulent Mach number evaluated at 1 pc, M_{1pc}, are derived for an ensemble of clouds including the Rosette and G216-2.5 regions that span a large range in star formation activity. We find no evidence for the positive correlations between these quantities and the star formation efficiency that are predicted by turbulent fragmentation models. A correlation does exist between the star formation efficiency and the sonic scale for a subset of clouds with $L_{FIR}/M(H_2) > 1$ that are generating young stellar clusters. Turbulent fragmentation must play a limited and nonexclusive role in determining the yield of stellar masses within interstellar clouds.

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Probable detection of H_2D^+ in the starless core Barnard 68

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The presence of H_2D^+ in dense cloud cores underlies ion-molecule reactions that strongly enhance the deuterium fractionation of many molecular species. We determine the H_2D^+ abundance in one starless core, Barnard 68, that has a particularly well established physical, chemical, and dynamical structure. We observed the ortho-H_2D^+ ground-state line 1_{10}–1_{11}, the N_2H^+ J=4–3 line, and the $H^{13}CO^+$ 4–3 line with the APEX telescope. We report the probable

detection of the o-H_2D^+ line at an intensity $T_{\rm mb}$=0.22 ± 0.08 K and exclusively thermal line width, and find only upper limits to the N_2H^+ 4–3 and $H^{13}CO^+$ 4–3 intensities. Within the uncertainties in the chemical reaction rates and the collisional excitation rates, chemical model calculations and excitation simulations reproduce the observed intensities and that of o-H_2D^+ in particular.

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Millimeter Multiplicity in NGC 6334 I and I(N)

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Using the Submillimeter Array (SMA), we have imaged the 1.3 millimeter continuum emission at the center of the massive star-forming regions NGC 6334 I and I(N). In both regions, the SMA observations resolve the emission into multiple millimeter sources, with most of the sources clustered into areas only 10,000 AU in diameter. Toward NGC 6334 I, we find four compact sources: the two brightest (I-SMA1 and I-SMA2) are associated with previously-known ammonia cores; I-SMA3 is coincident with the peak of the compact HII region (NGC 6334 F); and I-SMA4 is a newly-discovered object. While I-SMA3 exhibits a mixture of free-free and dust emission, the rest of the objects are dust cores. Toward NGC 6334 I(N), seven compact dust cores are found, one of which is associated with a faint centimeter source. With the exception of I-SMA3, none of the millimeter sources have infrared counterparts in Spitzer Space Telescope 3-8 micron images. Using a simple physical model for the dust continuum emission, the estimated mass of interstellar material toward each of these compact objects is in the range of 3 to 66 solar masses. The total mass in the compact objects appears to be similar in I and I(N). The small size of these groups of sources suggest that these objects are proto-Trapezia forming in the centers of clusters of low to intermediate-mass stars.

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On the ionisation fraction in protoplanetary disks III. The effect of X–ray flares on gas-phase chemistry

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Context: Recent observations of the X–ray emission from T Tauri stars in the Orion nebula have shown that they undergo frequent outbursts in their X–ray luminosity. These X–ray flares are characterised by increases in luminosity by two orders of magnitude, a typical duration of less than one day, and a significant hardening of the X–ray spectrum.

Aims: It is unknown what effect these X–ray flares will have on the ionisation fraction and dead–zone structure in protoplanetary disks. We present the results of calculations designed to address this question.

Methods: We have performed calculations of the ionisation fraction in a standard α–disk model using two different chemical reaction networks. We include in our models ionisation due to X–rays from the central star, and calculate the time–dependent ionisation fraction and dead–zone structure for the inner 10 AU of a protoplanetary disk model.

Results: We find that the disk response to X–ray flares depends on whether the plasma temperature increases during flares and/or whether heavy metals (such as magnesium) are present in the gas phase. Under favourable conditions the outer disk dead–zone can disappear altogether, and the dead–zone located between $0.5 < R < 2$ AU can disappear and reappear in phase with the X–ray luminosity.

Conclusions: X–ray flares can have a significant effect on the dead–zone structure in protoplanetary disks. Caution is required in interpreting this result as the duration of X–ray bursts is considerably shorter than the growth time of MHD turbulence due to the magnetorotational instability.

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Orbital Stability of Protoplanetary Systems in Nebular Gas and Implications for Terrestrial Planet Formation

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The oligarchic growth model of planetary accretion predicts the formation of protoplanets of similar sizes, and the final stage of terrestrial planet formation involves long-term orbital instability and mutual collision of protoplanets through their gravitational interaction. However, the mass of the protoplanets formed by oligarchic growth depends on the initial surface density of the protoplanetary disk, as well as the distance from the central star. In order to better understand the final stage of terrestrial planet formation in disks with various profiles, we perform orbital integration for systems of five protoplanets and examine the dependence of the orbital instability timescale of the systems on the mass of the protoplanets, M_p, both with and without nebular gas. Previous studies have shown that the timescale for orbital instability in the absence of nebular gas increases exponentially with the initial semimajor axis difference between the protoplanets. We find that the exponential constant is independent of the mass of the protoplanets, as long as the initial separation is measured in units of $\sim {M_p}^{0.29}$, which is very close to the previously derived mass dependence of the critical separation for the onset of chaotic behavior in the restricted circular three-body problem. In the presence of nebular gas, on the other hand, protoplanetary systems are stabilized by gas drag and experience no orbital instability when the initial semimajor axis difference is larger than a certain critical value. Using these results, we discuss the orbital stability of protoplanetary systems in disks with various surface densities.

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Accretion Disks around Young Stars: Lifetimes, Disk Locking and Variability

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We report the findings of a comprehensive study of disk accretion and related phenomena in four of the nearest young stellar associations spanning 6-30 million years in age, an epoch that may coincide with the late stages of planet formation. We have obtained ∼650 multi-epoch high-resolution optical spectra of 100 low-mass stars that are likely members of the η Chamaeleontis (∼6 Myr), TW Hydrae (∼8 Myr), β Pictoris (∼12 Myr) and Tucanae-Horologium (∼30 Myr) groups. Our data were collected over 12 nights between 2004 December - 2005 July on the Magellan Clay 6.5m telescope. Based on Hα line profiles, along with a variety of other emission lines, we find clear evidence of on-going accretion in three out of 11 η Cha stars and two out of 32 TW Hydrae members. None of the 57 β Pic or Tuc-Hor members shows measurable signs of accretion. Together, these results imply significant evolution of the disk accretion process within the first several Myr of a low-mass star's life. While a few disks can continue to accrete for up to ∼10 Myr, our findings suggest that disks accreting for beyond that timescale are rather rare. This result provides an indirect constraint on the timescale for gas dissipation in inner disks and, in turn, on gas giant planet formation. All accretors in our sample are slow rotators, whereas non-accretors cover a large range in rotational velocities. This may hint at rotational braking by disks at ages up to ∼8 Myr. Our multi-epoch spectra confirm that emission-line variability is common even in somewhat older T Tauri stars, among which accretors tend to show particularly strong variations. Thus, our results indicate that accretion and wind activity undergo significant and sustained variations throughout the lifetime of accretion disks.

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Turbulent diffusion in protoplanetary discs: The effect of an imposed magnetic field

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We study the effect of an imposed vertical magnetic field on the turbulent mass diffusion properties of magnetorotational turbulence in protoplanetary discs. It is well-known that the effective viscosity generated by the turbulence depends strongly on the magnitude of such an external field. In this letter we show that the turbulent diffusion of the flow also grows, but that the diffusion coefficient does not rise with increasing vertical field as fast as the viscosity does. The vertical Schmidt number, i.e. the ratio between viscosity and vertical diffusion, can be close to 20 for high field magnitudes, whereas the radial Schmidt number is increased from below unity to around 3.5. Our results may have consequences for the interpretation of observations of dust in protoplanetary discs and for chemical evolution modelling of these discs.

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The Frequency of Binary Kuiper Belt Objects

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We estimate the frequency of widely spaced (separations greater than 0.5") Kuiper Belt binaries (KBBs) from surveys for new Kuiper Belt objects (KBOs) with the Deep Ecliptic Survey and through recovery observations for newly discovered KBOs at the Magellan telescopes. We find the frequency of KBBs versus discovery separation to be related by an inverse power law when combining our results with those for the fraction of close binaries (separations less than 0.5") found in the literature. For wide separations, our data and the resulting model agree with the model proposed by Goldreich et al. in 2002. However, including the frequency at the smallest separation rules out the semimajor-axis dependence of the Goldreich et al. model at the 99% confidence level, indicating that there is likely a turnover in the distribution at very close separations, or that the number of close binaries has been underestimated. In either case, the binary-frequency distribution favors binary formation models invoking gravitational rather than physical interactions—such as those proposed by Goldreich et al. and Astakhov et al. (2005).

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Formation of Terrestrial Planets from Protoplanets. I. Statistics of Basic Dynamical Properties

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The final stage of terrestrial planet formation is known as the giant impact stage, where protoplanets collide with one another to form planets. As this process is stochastic, in order to clarify it, it is necessary to quantify it statistically. We investigate this final assemblage of terrestrial planets from protoplanets using N-body simulations. As initial

conditions, we adopt the oligarchic growth model of protoplanets. We systematically change the surface density, surface density profile, and orbital separation of the initial protoplanet system, and the bulk density of protoplanets, while the initial system radial range is fixed at 0.5–1.5 AU. For each initial condition, we perform 20 runs, and from their results we derive the statistical properties of the assembled planets. For the standard disk model, typically two Earth-sized planets form in the terrestrial planet region. We show the dependences of the masses and orbital elements of planets on the initial protoplanet system parameters and give their simple empirical fits. The number of planets slowly decreases as the surface density of the initial protoplanets increases, while the masses of individual planets increase almost linearly. For a steeper surface density profile, large planets tend to form closer to the star. For the parameter ranges that we test, the basic structure of planetary systems depends only slightly on the initial distribution of protoplanets and the bulk density as long as the total mass is fixed.

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Radial distribution of planets. Predictions based on the core-accretion gas-capture planet-formation model.

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We have investigated the problem of the distribution of both masses and orbital radii of planets resulting from the gas-accretion, gas-capture model. First we followed the evolution of gas and solids from the moment where all solids are in the form of small grains to the stage when most of them are in the form of planetesimals for a set of different initial masses and sizes of protoplanetary disks. Based on that we performed Monte Carlo calculations describing the formation of giant places at different locations. We included the effects of type II migration and growth of the mass of the planet after the gap opened. We discuss how these effects influence the final distribution of giant planets. We show that when the giant planets are not able to migrate or grow in mass after the gap opens, their distribution is mainly determined by the properties of the gaseous disk. However, with those two effects included, reproducing the parameters of the gaseous disks from the distribution of planets becomes difficult. We also checked the roles of both the material of which the solids consist and the mass of the central star. The main result is that, in disks around less massive stars, giant planets at the given location tend to be less massive. At the same time, the giant planets with the given mass tend to form closer to the less massive stars.

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Formation of giant planets around stars with various masses

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We examine the predictions of the core accretion - gas capture model concerning the efficiency of planet formation around stars with various masses. First, we follow the evolution of gas and solids from the moment when all solids are in the form of small grains to the stage when most of them are in the form of planetesimals. We show that the surface density of the planetesimal swarm tends to be higher around less massive stars. Then, we derive the minimum surface density of the planetesimal swarm required for the formation of a giant planet both in a numerical and in an approximate analytical approach. We combine these results by calculating a set of representative disk models characterized by different masses, sizes, and metallicities, and by estimating their capability of forming giant planets. Our results show that the set of protoplanetary disks capable of giant planet formation is larger for less massive stars. Provided that the distribution of initial disk parameters does not depend too strongly on the mass of the central star, we predict that the percentage of stars with giant planets should increase with decreasing stellar mass. Furthermore, we identify the radial redistribution of solids during the formation of planetesimal swarms as the key element in explaining these effects.

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On the formation of Hα line emission around classical T Tauri stars

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We present radiative transfer models of the circumstellar environment of classical T Tauri stars, concentrating on the formation of the Hα emission. The wide variety of line profiles seen in observations are indicative of both inflow and outflow, and we therefore employ a circumstellar structure that includes both magnetospheric accretion and a disc wind. We perform systematic investigations of the model parameters for the wind and the magnetosphere to search for possible geometrical and physical conditions which lead to the types of profiles seen in observations. We find that the hybrid models can reproduce the wide range of profile types seen in observations, and that the most common profile types observed occupy a large volume of parameter space. Conversely, the most infrequently observed profile morphologies require a very specific set of models parameters. We find our model profiles are consistent with the canonical value of the mass-loss rate to mass-accretion rate ratio ($\mu = 0.1$) found in earlier magneto-hydrodynamic calculations and observations, but the models with $0.05 < \mu < 0.2$ are still in accord with observed Hα profiles. We investigate the wind contribution to the line profile as a function of model parameters, and examine the reliability of Hα as a mass accretion diagnostic. Finally, we examine the Hα spectroscopic classification used by Reipurth et. al, and discuss the basic physical conditions that are required to reproduce the profiles in each classified type.

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http://www.arxiv.org/abs/astro-ph/0605234 or http://www.astro.ex.ac.uk/people/rk/profiles

The Spitzer c2d Survey of Nearby Dense Cores: III: Low Mass Star Formation in a Small Group, L1251B

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We present a comprehensive study of a low-mass star-forming region, L1251B, at wavelengths from the near-infrared to the millimeter. 1251B, where only one protostar, IRAS 22376+7455, was known previously, is confirmed to be a small group of protostars based on observations with the Spitzer Space Telescope. The most luminous source of L1251B is located 5" north of the IRAS position. A near-infrared bipolar nebula, which is not associated with the brightest object and is located at the southeast corner of L1251B, has been detected in the IRAC bands. OVRO and SMA interferometric observations indicate that the brightest source and the bipolar nebula source in the IRAC bands are deeply embedded disk sources. Submillimeter continuum observations with single-dish telescopes and the SMA interferometric observations suggest two possible prestellar objects with very high column densities. Outside of the small group, many young stellar object candidates have been detected over a larger region of 12' x 12'. Extended

emission to the east of L1251B has been detected at 850 micron; this "east core" may be a site for future star formation since no point source has been detected with IRAC or MIPS. This region is therefore a possible example of low-mass cluster formation, where a small group of pre- and protostellar objects (L1251B) is currently forming, alongside a large starless core (the east core).

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http://peggysue.as.utexas.edu/SIRTF/PAPERS/pap27.pub.pdf (or astro-ph/0605475)

Rapid star formation in the presence of active galactic nuclei

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Recent observations reveal galaxies in the early Universe ($2 < z < 6.4$) with large reservoirs of molecular gas and extreme star formation rates. For a very large range of sources, a tight relationship exists between star formation rate and the luminosity of the HCN J=1-0 spectral line, but sources at redshifts of z∼ 2 and beyond do not follow this trend. The deficit in HCN is conventionally explained by an excess of infrared (IR) radiation due to active galactic nuclei (AGN). We show in this letter not only that the presence of AGN cannot account for the excess of IR over molecular luminosity, but also that the observed abundance of HCN is in fact consistent with a population of stars forming from near-primordial gas.

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Dynamical H II Region Evolution in Turbulent Molecular Clouds

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We present numerical radiation-hydrodynamic simulations of the evolution of H II regions formed in an inhomogeneous medium resulting from turbulence simulations. We find that the filamentary structure of the underlying density distribution produces a highly irregular shape for the ionized region, in which the ionization front escapes to large distances in some directions within 80,000 years. In other directions, on the other hand, neutral gas in the form of dense globules persists within 1 parsec of the central star for the full duration of our simulation (400,000 years). Divergent photoablation flows from these globules maintain a root-mean-squared velocity in the ionized gas that is close to the ionized sound speed. Simulated images in optical emission lines show morphologies that are in strikingly detailed agreement with those observed in real H II regions.

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http://arxiv.org/abs/astro-ph/0512554 or http://ifront.org/wiki/Turbulent_Hii_Regions/Papers

Triggered star formation in bright-rimmed clouds: the Eagle nebula revisited

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A three-dimensional smoothed particle hydrodynamics model has been extended to study the radiation-driven implosion effect of massive stars on the dynamical evolution of surrounding molecular clouds. The new elements in the upgraded code are the inclusion of Lyman continuum in the incident radiation flux and the treatment of hydrogen ionization process; the introduction of ionization heating and recombination cooling effects; and the addition of a proper description of the magnetic and turbulent pressures to the internal pressure of the molecular cloud. This extended code not only provides a realistic model to trace the dynamical evolution of a molecular cloud, but also can be used to model the kinematics of the ionization and shock fronts and the photoevaporating gas surrounding the molecular cloud, which the previous code is unable to handle.

The application of this newly developed model to the structure of the middle Eagle nebula finger suggests that the shock induced by the ionizing radiation at the front side of the head precedes an ionization front moving towards the centre of the core, and that the core at the fingertip is at a transition stage evolving toward a state of induced star formation. The dynamical evolution of the velocity field of the simulated cloud structure is discussed to illustrate the role of the self-gravity and the different cloud morphologies which appear at different stages in the evolutionary process of the cloud. The motion of the ionization front and the evaporating gas are also investigated. The modelled gas evaporation rate is consistent with that of other current models and the density, temperature and chemical profiles are in agreement with the observed values.

The relative lifetimes of different simulated cloud morphologies suggest a possible answer to the question of why more bright-rimmed clouds are observed to possess a flat-core than an elongated-core morphology.

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Bright Localized Near-Infrared Emission at 1-4 AU in the AB Aurigae Disk Revealed by IOTA Closure Phases

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We report on the detection of localized off-center emission at 1-4 AU in the circumstellar environment of the young stellar object AB Aurigae. We used closure phase measurements in the near-infrared made at the long baseline interferometer IOTA, the first obtained on a young stellar object using this technique. When probing sub-AU scales, all closure phases are close to zero degrees, as expected given the previously-determined size of the AB Aurigae inner dust disk. However, a clear closure phase signal of -3.5 +/- 0.5 degrees is detected on one triangle containing relatively short baselines, requiring a high degree of non-point symmetry from emission at larger (AU-sized) scales in the disk. We have not identified any alternative explanation for these closure phase results and demonstrate that a "disk hot spot" model can fit our data. We speculate that such asymmetric near-infrared emission detected might arise as a result of localized viscous heating due to a gravitational instability in the AB Aurigae disk, or to the presence of a close stellar companion or accreting sub-stellar object.

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Few Skewed Disks Found in First Closure-Phase Survey of Herbig Ae/Be stars

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Using the 3-telescope IOTA interferometer on Mt. Hopkins, we report results from the first near-infrared ($\lambda = 1.65\mu$m) closure-phase survey of Young Stellar Objects (YSOs). These closure phases allow us to unambiguously detect departures from centrosymmetry (i.e., skew) in the emission pattern from YSO disks on the scale of ∼4 milliarcseconds, expected from generic "flared disk" models. Six of fourteen targets showed small, yet statistically-significant, non-zero closure phases, with largest values from the young binary system MWC 361-A and the (pre-main sequence?) Be star HD 45677. Our observations are quite sensitive to the *vertical* structure of the inner disk and we confront the predictions of the "puffed-up inner wall" models of Dullemond, Dominik, and Natta (DDN). Our data support disks models with *curved* inner rims because the expected emission appear symmetrically-distributed around the star over a wide range of inclination angles. In contrast, our results are *incompatible* with the models possessing *vertical* inner walls because they predict extreme skewness (i.e., large closure phases) from the near-IR disk emission that is not seen in our data. In addition, we also present the discovery of mysterious H-band "halos" (∼5-10% of light on scales 0.01-0.50″) around a few objects, a preliminary "parametric imaging" study for HD 45677, and the first astrometric orbit for the young binary MWC 361-A.

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`http://www.astro.lsa.umich.edu/~monnier/Publications/monnier_ionic3_2006.pdf`

An Outbursting Protostar of the FU Orionis type in the Cygnus OB7 Molecular Cloud

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Context : To follow the early evolution of stars we need to understand how young stars accrete and eject mass. It is generally assumed that the FU Orionis phenomenon is related to the variations in the disk accretion, but many questions remain still open, in particular because of the rarity of FU Ori type stars.

Aims : We explore here the characteristics of the outburst and of the environment of one new object, discovered recently in the in the active star formation region containing RNO 127, within the Cygnus OB7 dark cloud complex.

Methods : We present an extensive optical and near-infrared study of a new candidate of FU Orionis object, including its direct imaging, spectroscopy and scanning Fabry-Pérot interferometry.

Results : The source, associated with the variable reflection nebula, underwent prodigious outburst. The "Braid" nebula, which appeared in 2000, as is indicated by its name, consists of two intertwined features, illuminated by the outburst. Subsequent NIR observations revealed the bright source, which was not visible on 2MASS images, and its estimated brightening was more than 4 magnitudes. Optical and infrared spectral data show features, which are

necessary for the system to be referred to as a **FUor** object. The bipolar optical flow directed by the axis of nebula also was found. Various estimates give the November/December 1999 as the most probable date for the eruption.

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http://www.astro.up.pt/∼khtig/publications.php

Accretion in the ρ-Ophiuchi pre-main sequence stars

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Aims. The aim of this paper is to provide a measurement of the mass accretion rate in a large, complete sample of objects in the core of the star forming region ρ Oph.

Methods. The sample includes most of the objects (104 out of 111) with evidence of a circumstellar disk from mid-infrared photometry; it covers a stellar mass range from about 0.03 to 3 $M_\odot$ and it is complete to a limiting mass of $\sim 0.05 M_\odot$. We used J and K-band spectra to derive the mass accretion rate of each object from the intensity of the hydrogen recombination lines, Paβ or Brγ. For comparison, we also obtained similar spectra of 35 diskless objects.

Results. The results show that emission in these lines is only seen in stars with disks, and can be used as an indicator of accretion. However, the converse does not hold, as about 50% of our disk objects do not have detectable line emission. The measured accretion rates show a strong correlation with the mass of the central object ($\dot{M}_{acc} \propto M_\star^{1.8\pm0.2}$) and a large spread, of two orders of magnitude at least, for any interval of $M_\star$. A comparison with existing data for Taurus shows that the objects in the two regions have similar behaviour, at least for objects more massive than $\sim 0.1 M_\odot$. The implications of these results are briefly discussed.

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The Two Young Star Disks in the Central Parsec of the Galaxy: Properties, Dynamics, and Formation

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We report the definite spectroscopic identification of $\simeq$ 40 OB supergiants, giants, and main-sequence stars in the central parsec of the Galaxy. Detection of their absorption lines has become possible with the high spatial and spectral resolution and sensitivity of the adaptive optics integral field spectrometer SPIFFI/SINFONI on the ESO VLT. Several of these OB stars appear to be helium- and nitrogen-rich. Almost all of the $\simeq$ 80 massive stars now known in the central parsec (central arcsecond excluded) reside in one of two somewhat thick ($\langle h \rangle / R \simeq 0.14$) rotating disks. These

stellar disks have fairly sharp inner edges ($R \simeq 1$") and surface density profiles that scale as R^{-2}. We do not detect any OB stars outside the central 0.5 pc. The majority of the stars in the clockwise system appear to be on almost circular orbits, whereas most of those in the "counterclockwise" disk appear to be on eccentric orbits. Based on its stellar surface density distribution and dynamics, we propose that IRS 13E is an extremely dense cluster ($\rho_{core} \geq 3 \times 10^8 M_\odot$ pc^{-3}) that has formed in the counterclockwise disk. The stellar contents of both systems are remarkably similar, indicating a common age of $\simeq 6 \pm 2$ Myr. The K-band luminosity function of the massive stars suggests a top-heavy mass function and limits the total stellar mass contained in both disks to $\simeq 1.5 \times 10^4 M_\odot$. Our data strongly favor in situ star formation from dense gas accretion disks for the two stellar disks. This conclusion is very clear for the clockwise disk and highly plausible for the counterclockwise system.

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Recipes for stellar jets: results of combined optical/infrared diagnostics

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We examine the conditions of the plasma along a sample of 'classical' Herbig-Haro (HH) jets located in the Orion and Vela star forming regions, through combined optical-infrared spectral diagnostics. Our sample includes HH 111, HH 34, HH 83, HH 73, HH 24 C/E, HH 24 J, observed quasi-simultaneously and in the same manner at moderate spatial/spectral resolution. Once inter-calibrated, the obtained spectra cover a wide wavelength range from 0.6 - 2.5 μm, including many transitions from regions of different excitation conditions. This allows us to probe the density and temperature stratification which characterises the cooling zones behind the shock fronts along the jet. ¿From the line ratios we derive the variation of the visual extinction along the flow, the electron density and temperature (n_e and T_e), the hydrogen ionisation fraction x_e, and the total density n_H in the emission region of different lines. The knowledge of such parameters is essential for testing existing jet models and for planning follow-up high-angular resolution observations.

From the diagnostics of optical forbidden lines we find, on average, that in the examined jets, in the region of optical emission, n_e varies between 50 cm^{-3} and 3 10^3 cm^{-3}, x_e ranges between 0.03 and 0.6, and the electron temperature T_e is ~1.3 10^4 K in the HH 111 and HH 34 jets, while it appears to be higher (1.8 10^4 K on average) in the other examined jets. The electron density and temperature derived from [Fe II] lines, turn out to be, respectively, higher and lower in comparison to those determined from optical lines, in agreement with the fact that the [Fe II] lines arise in the more compressed gas located further from the shock front. An even denser component in the jets, with values of n_e up to 10^6 cm^{-3} is detected using the ratio of Calcium lines.

The derived physical parameters are used to estimate the depletion onto dust grains of Calcium and Iron with respect to solar abundances. This turns out to be quite substantial, being between 70% and 0% for Ca and ~90% for Fe. This leads us to suggest that the weak shocks present in the beams are not capable of completely destroying the ambient dust grains, confirming previous theoretical studies. We then derive the mass flux rates, $\dot{M}_{\rm jet}$, in the flows using two independent methods. Taking into account the filling factor of the emitting gas, $\dot{M}_{\rm jet}$ is on average 5 10^{-8} $M_\odot$ yr^{-1}. The associated linear momentum fluxes ($\dot{P}_{\rm jet} = v_{jet}\dot{M}_{\rm jet}$) are higher than, or of the same order as, those measured in the coaxial molecular flows, where present, suggesting that the flows are jet driven.

Finally, we discuss differences between jets in our sample. In general, we find that higher ionisation and electron temperatures are associated with less dense jets. The comparison suggests that the shock mechanism exciting the knots along the flows has the same efficiency in all the examined objects, and the observed differences are consistent with the different densities, and hence cooling rates, found in the various flows.

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Spatial mapping of ices in the Oph-F core: A direct measurement of CO depletion and the formation of CO_2

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Aims: Ices in dense star-forming cores contain the bulk of volatile molecules apart from H_2 and thus represent a large fraction of dark cloud chemistry budget. Mm observations of gas provide indirect evidence for significant freeze-out of CO in the densest cores. To directly constrain the freeze-out profile of CO, the formation route of CO_2 and the carrier of the 6.8 μm band, the spatial distribution of the CO/CO_2 ice system and the 6.8 μm band carrier are measured in a nearby dense core.

Methods: VLT-ISAAC, ISOCAM-CVF and Spitzer-IRS archival mid-infrared (3-20 μm) spectroscopy of young stellar objects is used to construct a map of the abundances of CO and CO_2 ices in the Oph-F star-forming core, probing core radii from 2×10^3 to 14×10^3 AU or densities from 5×10^4 to $5 \times 10^5\,\mathrm{cm}^{-3}$ with a resolution of ~ 3000 AU.

Results: The line-of-sight averaged abundances relative to water ice of both CO and CO_2 ices increase monotonously with decreasing distance to the core center. The map traces the shape of the CO abundance profile between freeze-out ratios of 5–60% and shows that the CO_2 ice abundance increases by a factor of 2 as the CO freezes out. It is suggested that this indicates a formation route of CO_2 on a CO ice surface to produce a CO_2 component dilute in CO ice, in addition to a fraction of the CO_2 formed at lower densities along with the water ice mantle. It is predicted that the CO_2 bending mode band profile should reflect a high CO:CO_2 number ratio in the densest parts of dark clouds. In contrast to CO and CO_2, the abundance of the carrier of the 6.8 μm band remains relatively constant throughout the core. A simple freeze-out model of the CO abundance profile is used to estimate the binding energy of CO on a CO ice surface to 814 ± 30 K.

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FU Orionis - The MIDI/VLTI Perspective

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We present the first mid-infrared interferometric measurements of FU Orionis. We clearly resolve structures that are best explained with an optically thick accretion disk. A simple accretion disk model fits the observed SED and visibilities reasonably well and does not require the presence of any additional structure such as a dusty envelope. The inclination and also the position angle of the disk can be constrained from the multibaseline interferometric observations. Our disk model is in general agreement with most published near-infrared interferometric measurements. From the shape and strength of the 8-13 micrometer spectrum the dust composition of the accretion disk is derived for the first time. We conclude that most dust particles are amorphous and already much larger than those typically observed in the ISM. Although the high accretion rate of the system provides both, high temperatures out to large radii and an effective transport mechanism to distribute crystalline grains, we do not see any evidence for crystalline silicates neither in the total spectrum nor in the correlated flux spectra from the inner disk regions. Possible reasons for this non-detection are mentioned. All results are discussed in context with other high-spatial resolution observations of FU Ori and other FU Ori objects. We also address the question whether FU Ori is in a younger evolutionary stage than a classical TTauri star.

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Silicon and Nickel Enrichment in Planet Host Stars: Observations and Implications for the Core Accretion Theory of Planet Formation

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We present evidence that stars with planets exhibit statistically significant silicon and nickel enrichment over the general metal-rich population. We also present simulations that predict silicon enhancement of planet hosts within the context of the core accretion hypothesis for giant planet formation. Because silicon and oxygen are both α-elements, [Si/Fe] traces [O/Fe], so the silicon enhancement in planet hosts predicts that these stars are oxygen-rich as well. We present new numerical simulations of planet formation by core accretion that establish the timescale on which a Jovian planet reaches rapid gas accretion, t_{rga}, as a function of solid surface density σ_{solid}: $(t_{rga}/1\ \mathrm{Myr}) = (\sigma_{solid}/25.0\ \mathrm{g\ cm^{-2}})^{-1.44}$. This relation enables us to construct Monte Carlo simulations that predict the fraction of star-disk systems that form planets as a function of [Fe/H], [Si/Fe], disk mass, outer disk radius, and disk lifetime. Our simulations reproduce both the known planet-metallicity correlation and the planet-silicon correlation reported in this paper. The simulations predict that 15% of solar-type stars form Jupiter-mass planets, in agreement with 12% predicted from extrapolation of the observed planet frequency–semimajor axis distribution. Although a simple interpretation of core accretion predicts that the planet-silicon correlation should be much stronger than the planet-nickel correlation, we observe the same degree of silicon and nickel enhancement in planet hosts. If this result persists once more planets have been discovered, it might indicate a complexity in the chemistry of planet formation beyond the simple accumulation of solids in the core accretion theory.

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Low-mass star formation in R Coronae Australis: Observations of organic molecules with the APEX telescope

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This paper presents new APEX submillimetre molecular line observations of three low-mass protostars, IRS7A, IRS7B, and IRAS32, in the R Coronae Australis molecular cloud complex. The molecular excitation analysis is performed using a statistical equilibrium radiative transfer code. The derived beam averaged fractional abundances vary by less than a factor of two among the three sources, except those of H_2CO and CH_3OH, which show differences of about an order of magnitude. The molecular abundances are similar to those typically found in other star-forming regions in the Galaxy, such as the ρ Oph and Perseus molecular clouds. There is a marked difference in the kinetic temperatures derived for the protobinary source IRS7 from H_2CO ($\approx 40-60\,\mathrm{K}$) and CH_3OH ($\approx 20\,\mathrm{K}$), possibly indicating a difference in origin of the emission from these two molecules.

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Modeling the NIR-silhouette massive disk candidate in M17

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Aims: The physical properties of the massive disk candidate in the star-forming region M17 are analyzed.
Methods: Making use of the rare configuration that the gas and dust structure is seen in silhouette against the background radiation at $\lambda = 2.2$ μm, we determine the column density distribution from a high-resolution NAOS/CONICA image. The influence of scattered light on the mass determination is analyzed using 3D radiative transfer calculations. Further upper flux limits derived from observations with the Spitzer telescope at MIR wavelengths are used together with the NACO image to estimate the flux from the central object. For a range of stellar radii, stellar surface temperatures, and dust grain sizes, we apply three different models to account for the observed fluxes. The stability of the disk against self-gravitational forces is analyzed calculating the ratio of the gravitational acceleration by the central object and the disk, and the deviations from a Keplerian profile.
Results: We find that the column density is consistent with a central source being surrounded by a rotationally symmetric distribution of gas and dust. The extent of the symmetric disk part is about 3000 AU, with a warped point-symmetrical extension beyond that radius, and therefore larger than any circumstellar disk detected sofar. The modeling yields a radial density powerlaw exponent of -1.1 indicating a flat radial density distribution, and a large e-folding scale height ratio H/R of about 0.5. The mass of the entire disk estimated from the column density is discussed depending on the assumed distance and the dust model and ranges between 0.02 and 5 M_{sun}. We conclude that unless a star is located close to the disk in the foreground, scattered light will have little influence on the mass determination. We present a Spitzer image taken at $\lambda = 7.8$ μm with the disk seen in emission and identify polycyclic aromatic hydrocarbon (PAH) emission on the disk surface excited by the nearby massive stars as a possible source. Our 3D radiative transfer calculations for the scattered light image of the central source through an edge-on disk indicate that the elliptical shape seen in the NACO image does not require the assumption of a binary system and that it is consistent with a single object. We derive stellar main sequence masses of several M_{sun}, 50 M_{sun}, or 10 M_{sun}, depending on our assumptions that the extinction of the stellar flux is dominated (i) by the outer disk, (ii) by an inner disk comparable to the disks around intermediate-mass stars, or (iii) by an inner disk with dominating hot dust emission, respectively. We find that even for a star-disk mass ratio of 1, only the outer parts of the circumstellar disk may be influenced by self-gravity effects due to the large e-folding scale height ratio.

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On the origin of the X-ray emission from Herbig Ae/Be stars

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We performed a systematic search for Chandra archival observations of Herbig Ae/Be stars. These stars are fully radiative and not expected to support dynamo action analogous to their convective lower-mass counterparts, the T Tauri stars. Their X-ray emission has remained unexplained. The superior spatial resolution of Chandra with respect to previous X-ray instrumentation has allowed us to examine the possible role of late-type companions in generating the observed X-rays. In the total sample of 17 Herbig Ae/Be stars, 8 are resolved from X-ray emitting faint companions

or other unrelated X-ray bright objects within 10″. The detection fraction of Herbig Ae/Be stars is 76 %, but lowers to 35 % if all emission is attributed to further known and unresolved companions. The spectral analysis confirms the high X-ray temperatures ($\sim 20\,$MK) and large range of fractional X-ray luminosities ($\log L_{\rm x}/L_{star}$) of this class derived from earlier studies of individual objects. Radiative winds are ruled out as emission mechanism on basis of the high temperatures. The X-ray properties of Herbig Ae/Be stars are not vastly different from those of their late-type companion stars (if such are known), nor from other young late-type stars used for comparison. Therefore, either a similar kind of process takes place on both classes of objects, or there must be as yet undiscovered companion stars.

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Entrainment Mechanisms for Outflows in the L1551 Star-Forming Region

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We present high sensitivity ^{12}CO and ^{13}CO J=1→0 molecular line maps covering the full extent of the parsec scale L1551 molecular outflow, including the redshifted east-west (EW) flow. We also present ^{12}CO J=3→2 data that extends over a good fraction of the area mapped in the J=1→0 transition. We compare the molecular data to widefield, narrow-band optical emission in Hα. While there are multiple outflows in the L1551 cloud, the main outflow is oriented at 50° position angle and appears to be driven by embedded source(s) in the central IRS 5 region. The blueshifted outflowing molecular gas extends to the edge of the molecular cloud and beyond the last HH object, HH 256. On the contrary, the redshifted molecular gas terminates within the cloud, short of the most distant HH object, HH 286, which lies well beyond the cloud boundary. The J=3→2 data indicate that there may be molecular emission associated with the L1551 NE jet, within the redshifted lobe of main outflow. We have also better defined the previously known EW flow and believe we have identified its blueshifted counterpart. We further speculate that the origin of the EW outflow lies near HH 102. We use velocity dependent opacity correction to estimate the mass and the energy of the outflow. The resulting mass spectral indices from our analysis, are systematically lower (less steep) than the power law indices obtained towards other outflows in several recent studies that use a similar opacity correction method. We show that systematic errors and biases in the analysis procedures for deriving mass spectra could result in errors in the determination of the power-law indices. The mass spectral indices, the morphological appearance of the position-velocity plots and integrated intensity emission maps of the molecular data, compared with the optical, suggest that jet-driven bow-shock entrainment is the best explanation for the driving mechanism of outflows in L1551. The kinetic energy of the outflows is found to be comparable to the binding energy of the cloud and sufficient to maintain the turbulence in the L1551 cloud.

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http://www.astro.umass.edu/∼irena/ms.ps.gz or http://arxiv.org/abs/astro-ph/0606242

On the internal structure of starless cores II. A molecular survey of L1498 and L1517B

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Context. Low mass starless cores present an inhomogeneous chemical composition. Species like CO and CS deplete at their dense interiors, while N_2H^+ and NH_3 survive in the gas phase. As molecular line observations are used to determine the physical conditions and kinematics of the core gas, chemical inhomogeneities can introduce a serious bias.

Aims. We have carried out a molecular survey towards two starless cores, L1498 and L1517B. These cores have been selected for their relative isolation and close-to-round shape. They have been observed in a number of lines of

13 molecular species in order to determine a self-consistent set of abundance profiles.

Methods. In a previous paper we modeled the physical structure of L1498 and L1517B. Here we use this work together with a spherically-symmetric Monte Carlo radiative transfer code to determine the radial profile of abundance for each species in the survey. Our model aims to fit simultaneously the radial profile of integrated intensity and the emerging spectrum from the core center.

Results. L1498 and L1517B present similar abundance patterns, with most species suffering a significant drop toward the core center. This occurs for CO, CS, CH_3OH, SO, C_3H_2, HC_3N, C_2S, HCN, H_2CO, HCO^+, and DCO^+, which we fit with profiles having a sharp central hole. The size of this hole varies with molecule: DCO^+, HCN, and HC_3N have the smallest holes, while SO, C_2S and CO have the largest holes. Only N_2H^+ and NH_3 seem present in the gas phase at the core centers.

Conclusions. From the different behavior of molecules, we select SO, C_2S, and CH_3OH as the most sensitive tracers of molecular depletion. Comparing our abundance determinations with the predictions from current chemical models we find order of magnitude discrepancies. Finally, we show how the "contribution function" can be used to study the formation of line profiles from the different regions of a core.

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Relative velocities among accreting planetesimals in binary systems: The circumprimary case

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We investigate classical planetesimal accretion in a binary star system of separation $a_b \leq 50$ AU by numerical simulations, with particular focus on the region at a distance of 1 AU from the primary. The planetesimals orbit the primary, are perturbed by the companion and are in addition subjected to a gas drag force. We concentrate on the problem of relative velocities Δv among planetesimals of different sizes. For various stellar mass ratios and binary orbital parameters we determine regions where Δv exceed planetesimal escape velocities v_{esc} (thus preventing runaway accretion) or even the threshold velocity v_{ero} for which erosion dominates accretion. Gaseous friction has two crucial effects on the velocity distribution: it damps secular perturbations by forcing periastron alignment of orbits, but at the same time the size-dependence of this orbital alignment induces a significant Δv increase between bodies of different sizes. This differential phasing effect proves very efficient and almost always increases Δv to values preventing runaway accretion, except in a narrow $e_b \simeq 0$ domain. The erosion threshold $\Delta v > v_{ero}$ is reached in a wide (a_b, e_b) space for small < 10-km planetesimals, but in a much more limited region for bigger $\simeq$ 50-km objects. In the intermediate $v_{esc} < \Delta v < v_{ero}$ domain, a possible growth mode would be the type II runaway growth identified by Kortenkamp et al. [Kortenkamp, S., Wetherill, G., Inaba, S., 2001. Science 293, 1127–1129].

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APEX mapping of H_3O^+ in the Sgr B2 region

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The cosmic-ray ionization rate $\zeta_{\rm CR}$ of dense molecular clouds is a key parameter for their dynamics and chemistry. Variations of $\zeta_{\rm CR}$ are well established, but it is unclear if these are related to source column density or to Galactic

location. Using the APEX telescope, we have mapped the 364 GHz line of H_3O^+ in the Sgr B2 region and observed the 307 GHz line at selected positions. With the IRAM 30-m telescope we have observed the $H_2^{18}O$ 203 GHz line at the same positions. Strong H_3O^+ emission is detected over a $\sim3\times2$ pc region, indicating an H_3O^+ column density of 10^{15}–10^{16} cm^{-2} in an 18″ beam. The H_3O^+ abundance of $\sim3\times10^{-9}$ and H_3O^+/H_2O ratio of $\sim1/50$ in the Sgr B2 envelope are consistent with models with $\zeta_{\rm CR}\sim4\times10^{-16}\,{\rm s}^{-1}$, 3× lower than derived from H_3^+ observations toward Sgr A, but 10× that of local dense clouds. The ionization rates of interstellar clouds thus seem to be to first order determined by the ambient cosmic-ray flux, while propagation effects cause a factor of ∼3 decrease from diffuse to dense clouds.

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Warm Molecular Gas in the Envelope and Outflow of IRAS 12496-7650 (DK Cha)

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Aims: To obtain insight into the physical structure of the warm gas in the inner envelope of protostars and the interaction with the outflow *Methods:* Sub-millimeter observations of ^{12}CO, ^{13}CO and/or C^{18}O in J=3–2, J=4–3 and J=7–6 were obtained with the APEX Telescope towards IRAS 12496-7650, an intermediate mass young stellar object. The data are compared to ISO-LWS observations of CO J=14–13 up to J=19–18 lines to test the different proposed origins of the CO lines. *Results:* The outflow is prominently detected in the 3–2 and 4–3 lines, but not seen at similar velocities in the 7–6 line, constraining the temperature in the high-velocity (> 5 km s^{-1} from line center) gas to less than 50 K, much lower than inferred from the analysis of the ISO-LWS data. In addition, no isothermal gas model can reproduce the emission in both the 7–6 and the higher-J ISO-LWS lines. The 7–6 line probably originates in the inner (<250 AU) region of the envelope at ∼150 K. Detailed radiative transfer calculations suggest that the ISO-LWS lines are excited by a different mechanism, possibly related to the larger-scale outflow. All possible mechanisms on scales smaller than 8″ are excluded. High-resolution continuum as well as high$-J$ ^{12}CO and isotopic line mapping are needed to better constrain the structure of the warm gas in the inner envelope and the interaction with the outflow.

Accepted by A&A special issue on APEX first results

Generation of density inhomogeneities by magnetohydrodynamic waves in two dimensions

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Using two dimensional simulations, we study the formation of structures with a high-density contrast by magnetohydrodynamic waves in regions in which the ratio of thermal to magnetic pressure is small. The initial state is a uniform background perturbed by fast-mode wave. Our most significant result is that dense structures persist for far longer in a two-dimensional simulation than in the one-dimensional case. Once formed, these structures persist as long as the fast-mode amplitude remains high.

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Molecular Cloud Evolution. – I. Molecular Cloud and Thin Cold Neutral Medium Sheet Formation

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We discuss molecular cloud formation by large-scale supersonic compressions in the diffuse warm neutral medium (WNM). Initially, a shocked layer forms, and within it, a thin cold layer. An analytical model and high-resolution one-dimensional simulations predict the thermodynamic conditions in the cold layer. After ~ 1 Myr of evolution, the layer has column density $\sim 2.5 \times 10^{19}$ cm^{-2}, thickness ~ 0.03 pc, temperature ~ 25 K, and pressure ~ 6650 K cm^{-3}. These conditions are strongly reminiscent of those recently reported by Heiles and coworkers for cold neutral medium sheets. In the one-dimensional simulations, the inflows into the sheets produce line profiles with a central line of width ~ 0.5 km s^{-1} and broad wings of width ~ 1 km s^{-1}. Three-dimensional numerical simulations show that the cold layer develops turbulent motions and increases its thickness until it becomes a fully three-dimensional turbulent cloud. Fully developed turbulence arises on times ranging from ~ 7.5 Myr for inflow Mach number $M_{1,r} = 2.4$ to > 80 Myr for $M_{1,r} = 1.03$. These numbers should be considered upper limits. The highest density turbulent gas (HDG, $n > 100$ cm^{-3}) is always overpressured with respect to the mean WNM pressure by factors of 1.5–4, even though we do not include self-gravity. The intermediate-density gas (IDG, $10 < n/\mathrm{cm}^{-3} < 100$) has a significant pressure scatter that increases with $M_{1,r}$, so that at $M_{1,r} = 2.4$ a significant fraction of the IDG is at a higher pressure than the HDG. Our results suggest that the turbulence and at least part of the excess pressure in molecular clouds can be generated by the compressive process that forms the clouds themselves and that thin CNM sheets may be formed transiently by this mechanism, when the compressions are only weakly supersonic.

Published by The Astrophysical Journal (Vol. 643, p. 245)

Revealing the environs of the remarkable southern hot core G327.3-0.6

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We present a submm study of the massive hot core G327.3-0.6 that constrains its physical parameters and environment. The APEX telescope was used to image CO and N2H+ emission, to observe lines from other molecules toward a hot and a cold molecular core, and to measure the continuum flux density of the hot core. In the C18O J=3-2 line, two clumps were found, one associated with the HII region G327.3-0.5 and the other associated with the hot core. An additional cold clump is found 30 arcsec (0.4 pc) northeast of the hot core in bright N2H+ emission. From the the continuum data, we calculate a mass of 420 Msol and a size of 0.1 pc for the hot core. A new, more accurate position of the hot core is reported, which allows the association of the core with a bright mid-infrared source. The luminosity of the hot core is estimated to be between 5 and 15 10^4 Lsol. This study revealed several different evolutionary stages of massive star formation in the G327.3-0.6 region.

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astro-ph/0605667

Mid- and high-J CO observations towards UCHIIs

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A study of 12 ultracompact HII regions was conducted to probe the physical conditions and kinematics in the inner envelopes of the molecular clumps harboring them. The APEX telescope was used to observe the sources in the CO (4-3) and 13CO (8-7) lines. Line intensities were modeled with the RATRAN radiative transfer code using power laws for the density and temperature to describe the physical structure of the clumps. All sources were detected in both lines. The optically thick CO (4-3) line shows predominantly blue skewed profiles reminiscent of infall. Line intensities can be reproduced well using the physical structure of the clumps taken from the literature. The optically thick line profiles show that CO is a sensitive tracer of ongoing infall in the outer envelopes of clumps harboring ultracompact HII regions and hot molecular cores.

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astro-ph/0605668

Deep Near-Infrared Imaging of an Embedded Cluster in the Extreme Outer Galaxy: Census of Supernovae Triggered Star Formation

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E-mail contact:

While conducting a near-infrared (NIR) survey of “Digel Clouds”, which are thought to be located in the extreme outer Galaxy (EOG), Kobayashi & Tokunaga found star formation activity in “Cloud 2”, a giant molecular cloud at the Galactic radius of $\sim$ 20 kpc. Additional infrared imaging showed two embedded young clusters at the densest regions of the molecular cloud. Because the molecular cloud is located in the vicinity of a supernova remnant (SNR) HI shell, GSH 138-01-94, it was suggested that the star formation activity in Cloud 2 was triggered by this expanding HI shell. We obtained deep J (1.25 μm), H (1.65 μm) and K (2.2 μm) images of one of the embedded clusters in Cloud 2 with high spatial resolution (FWHM $\sim$ 0”.3) and high sensitivity (K $\sim$ 20 mag, 10σ). We identified 52 cluster members. The estimated stellar density ($\sim$ 10 pc^{-2}) suggests that the cluster is a T-association. This is the deepest NIR imaging of an embedded cluster in the EOG. The observed K-band luminosity function (KLF) suggests that the underlying initial mass function (IMF) of the cluster down to the detection limit of $\sim 0.1 M_\odot$ is not significantly different from the typical IMFs in the field and in the near-by star clusters. The overall characteristics of this cluster appears to be similar to those of other embedded clusters in the far outer Galaxy. The estimated age of the cluster from the KLF, which is less than 1 Myr, is consistent with the view that the star formation was triggered by the HI shell whose age was estimated at 4.3 Myr (Stil & Irwin). The 3-dimensional geometry of SNR shell, molecular cloud and the embedded cluster, which is inferred from our data, as well as the cluster age strongly suggest that the star formation in Cloud 2 was triggered by the SNR shell.

Accepted by the Astrophysical Journal

astro-ph/0606023

Abstracts of recently accepted major reviews

How to move ionized gas: an introduction to the dynamics of H II regions

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This review covers the dynamic processes that are important in the evolution and structure of galactic H II regions, concentrating on an elementary presentation of the physical concepts and recent numerical simulations of H II region evolution in a non-uniform medium.

The contents are as follows:

1. The equations (Euler equations; Radiative transfer; Rate equations; How to avoid the dynamics; How to avoid the atomic physics).

2. Physical concepts (Static photoionization equilibrium; Ionization front propagation; Structure of a D-type front; Photoablation flows; Other ingredients – Stellar winds, Radiation pressure, Magnetic fields, Instabilities).

3. H II region evolution (Early phases: hypercompact and ultracompact regions; Later phases: compact and extended regions; Clumps and turbulence).

Accepted by 'Diffuse Matter from Star Forming Regions to Active Galaxies' – A Volume Honouring John Dyson. Eds. T. W. Harquist, J. M. Pittard and S. A. E. G. Falle.

http://arxiv.org/abs/astro-ph/0602626 or http://www.ifront.org/wiki/Dyson_Festschrift_Chapter

The Diffuse Interstellar Bands: A Major Problem in Astronomical Spectroscopy

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A critical review of the very long-standing problem of the diffuse interstellar bands is presented with emphasis on spectroscopic aspects of observational, modelling and laboratory-based research. Some research themes and ideas that could be explored theoretically and experimentally are discussed. The article is based on the Journal of Molecular Spectroscopy Review Lecture presented at the 60th Ohio State University International Symposium on Molecular Spectroscopy, June 2005.

Accepted by Journal of Molecular Spectroscopy

Maser Emission Associated with Young High Mass Stars

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Ph.D dissertation directed by: Gary Fuller

Ph.D degree awarded: June 2006

In this work the maser emission has been used to study the very early stage evolution of young high mass stars. The maser emission of OH molecule was searched for towards a sample of high mass protostellar objects using the Nançay and GBT telescopes. The sample of objects searched was selected to contain very young forming high mass star. The results of this survey have been compared with previous H_2O and CH_3OH masers observations. Then MERLIN has been used to map the OH as well as H_2O and CH_3OH masers towards one of these sources in high angular resolution.

The survey detected OH maser emission towards 63 objects with 37 new detections. There are 56 star forming regions and 7 OH/IR candidates. The detection of OH masers towards 26% of a sample of 217 sources should remove any doubt about the existence of OH maser emission towards these objects of this early evolutionary stage. Some of the detected sources are only associated with OH masers and some sources are only associated with the 1720 MHz OH maser line. Nearly half of the detected sources have OH fluxes ≤ 1 Jy. The velocity range of the maser emission suggest that the water maser sources may be divided into two groups, one of which may be related to the circumstellar disk while the other related to outflows. The results of detection rates and velocity range support the spatial association of OH and class II CH_3OH masers as suggested by Caswell et al. (1995) and modelled by Cragg et al. (2002).

IRAS20126+4104 was mapped in the OH, water and methanol masers using MERLIN. The 1665-MHz OH, 22-GHz H_2O and 6.7-GHz CH_3OH masers are detected and all originate very close to the central source. The OH and methanol masers appear to trace part of the circumstellar disk around the central source. The positions and velocities of the OH masers are consistent with Keplerian rotation around a central mass of $\sim 5\ M_\odot$. The water masers are offset from the OH and CH_3OH masers and have significantly changed since they were last observed, but still appear to be associated outflow from the source. All the OH masers components are circular polarized, in some cases reaching 100 percent while some OH components also have low levels of linear polarization. We identified one Zeeman pair and the splitting of this pair indicate the presence of a magnetic field of strength ~ 11 mG within $\sim 0.5''$ (850 AU) of the central source. The OH and CH_3OH maser emission suggest that the disk material is dense, $n > 10^6$ cm^{-3}, and warm, $T > 125$K and the high abundance of CH_3OH required by the maser emission is consistent with the evaporation of the mantles on dust grains in the disk as a result of heating or shocking of the disk material.

Quantifying the Role of Protostellar Outflows in Star Formation Feedback

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Ph.D dissertation directed by: John Bally

Ph.D degree awarded: April 2006

Star formation is a dynamic process in which newly formed stars interact with their parent molecular cloud. This feedback generates turbulence and gas motions which affects subsequent star formation within that cloud. Millimeter-wave observations of molecular clouds have revealed supersonic line widths, which are presumed to be due to turbulent motions. Supersonic turbulent energy, however, is expected to decay rapidly due to dissipation of energy in shocks.

If molecular clouds are long lived, then the turbulent motions must be constantly driven. On the other hand, if molecular clouds are destroyed on the scale of a few times the decay time, then the turbulence need not be driven, but the destruction mechanism must input significant energy and momentum into the cloud on that timescale. In either case, significant feedback must occur over a few Myr timescale. Protostellar outflows, collimated jets of material launched by accreting protostars, may be a significant source of feedback in regions which do not form high mass stars.

We explore different methods for probing the momentum injection rate of outflows and examine whether outflows can drive turbulence within the molecular cloud. On the scale of an entire molecular cloud, the shocks produced by outflows from young stars may not inject momentum at a sufficient rate to counter the rate at which momentum decays. However, intense outflow activity within individual cloud cores with high star formation rates, such as NGC 1333, may be sufficient to locally support or even disrupt the core.

http://www.ifa.hawaii.edu/users/joshw/

Postdoctoral Fellowship in UAM/INTA-LAEFF, Madrid, SPAIN

Postdoctoral Fellowship in UAM/INTA-LAEFF (Universidad Autonoma de Madrid/Laboratorio de Astrofisica Espacial y Fisica Fundamental).

A postdoctoral fellowship position is available at UAM/LAEFF under the project ASTRID (http:/www.astrid-cm-org), granted by the Comunidad Autonoma de Madrid (Spain). Administrative issues will be conducted by the Universidad Autonoma de Madrid.

The selected scientist will closely collaborate in the research lines carried out by the UAM/LAEFF group of ASTRID. Activity will be centered in the two following areas:

1. Star Formation and Substellar Objects

2. New optical/IR instrumental concepts for large telescopes (the Spanish 10m telescope GRANTECAN, VLT, ...) or simulations addressing astronomical data analysis of the new generation of space and ground-based observing facilities (Herschel, ALMA, GRANTECAN, JWST/MIRI, ...).

Eligible persons must have familiarity with current issues in the aforementioned areas, high motivation and own initiatives, as well as ability to pursue independent research within the research lines of the group.

Starting date is January 1st 2007. Duration is initially for 1 year and may be extended for another 1.5 years, depending on performance. Gross salary is approx. 22700 euros per year.

Applications should include curriculum vitae, publication list, letter stating research interests and two letters of reference.

Informal inqueries to Dr. Carlos Eiroa (carlos.eiroa@uam.es) or Dr. David Barrado (barrado@laeff.inta.es).

Applications should be sent by e-mail before August 31st 2006 to any of the given addresses (carlos.eiroa@uam.es; barrado@laeff.inta.es) or by post to:

Carlos Eiroa, Departamento de Fisica Teorica, Facultad de Ciencias, Universidad Autonoma de Madrid, Cantoblanco, 28049 Madrid, Spain

Postdoc in Massive Star Formation, Galway, Ireland

A Science Foundation Ireland funded postdoctoral research position is available from 1st September 2006 at the National University of Ireland, Galway working with Dr Matt Redman. The researcher will develop semi-analytic and numerical models of the accretion phase of massive star formation, taking into account the inhomogeneous nature of molecular clouds. The results with then be compared with observational molecular line profile data from telescopes such as the JCMT. The starting salary is 36,763 and the post is available for up to three years.

Candidates must have a PhD or else must have submitted their thesis before the start date and ideally should have 1) a background in star formation, molecular astrophysics or a related field and 2) experience in developing line radiative transfer, astrochemical or MHD/hydrodynamic codes.

Prospective applicants are encouraged to make informal contact with Matt Redman (matt.redman@nuigalway.ie) for further details on the post.

Applications consisting of a CV, publications list and short statement of research interests should be sent by email to matt.redman@nuigalway.ie. Applicants should also arrange for two letters of recommendation to be sent in the same way. Full consideration will be given to applications received by 10th July 2006.

Post-doctoral position in the Centre for Astrophysics at the University of Porto (Portugal)

The Centre for Astrophysics at the University of Porto (CAUP) invites applications for a post-doctoral position starting in September 2006. The position is for one year with a possible extension up to three years. Amount of the grant: 18,940 euros/year plus travel money.

The research at CAUP covers a range of topics within two broad areas:

1.Stellar Astrophysics (observations and models)

- star formation and early stages of evolution,
- young stellar objects,
- stellar and solar activity,
- winds, accretion, jets and HH objects,
- stellar structure,
- stellar seismology,
- optical interferometry.

2.Cosmology and Extragalactic Astronomy

Priority will be given to candidates with expertise in observational programmes (ground or space) or experience in instrumentation.

Applicants should forward to Prof. M.T.V.T. Lago (mtlago@astro.up.pt)

- a curriculum vitae,
- the list of publications,
- a brief description of past experience and research interests,
- a proposal for the research projects to be carried out at CAUP,
- name, position, address and email of three referees (reference letters will be requested for short listed candidates).

Inquiries can also be directed to mtlago@astro.up.pt and full details of the job are available at http://www.astro.up.pt/

Applications should be received at CAUP between 10th May and 30th June 2006. Short listed candidates will be contacted early July.

CAUP - Universidade do Porto, Rua das Estrelas, 4150 - 762 Porto, Portugal

Lecturer in Astronomy/Astrophysics

Applications are invited for a permanent Lectureship in Astronomy/Astrophysics. Deadline: June 1.

Research interests in Kent include star formation, the interstellar medium and numerical astrophysics. There are active experimental, theoretical and observational programmes which utilise ground-based and space-based observatories, and have full access to the UKs current range of facilities (including ESO, Gemini, UKIRT).

It is essential that applicants have a strong track record in, and commitment to, forefront research in astronomy and astrophysics. Applicants with a background in any area of observation or theory which complements or enhances the current programme are encouraged to apply.

The successful post holder will be expected to initiate, develop and deliver their own high quality research programme.

See: http://astro.kent.ac.uk or contact Prof. Michael D. Smith at m.d.smith@kent.ac.uk

Postdoctoral Fellowship at INTA-LAEFF (Laboratorio de Astrofisica Espacial y Fisica Fundamental).

A postdoctoral fellowship position is available at LAEFF under the project ASTRID (http://www.astrid-cm.org), granted by the Comunidad Autonoma de Madrid (Spain). Administrative issues will be conducted by INTA (Instituto Nacional de Tecnica Aeroespacial).

Requirements:

- PhD thesis in Astronomy (preferably in Radio Astronomy)

Desirable:

- Experience in observational Radio Astronomy - Experience in instrumentation - Programming skills

Preferable scientific lines

- Stellar formation (theory, observation)

Job description:

The Radio Astronomy team at LAEFF manages the Spanish time of the antennas at NASA's Deep Space Station in Robledo de Chavela (a minimum of 3% per year)

Robledo station has 6 antennas, one 70-meter and five 34-meter antennas. One of the 34-m is devoted exclusively to the PARTNeR educational program (http://www.laeff.inta.es/partner), also managed by the Radio Astronomy group at LAEFF. Regular spectroscopy observations in K-band are performed with the 70-meter antenna in single-dish mode.

All antennas, except for that of the PARTNeR program, are also used for VLBI observations within the EVN network. These observations are performed by Robledo staff, not by the LAEFF group.

The postdoc will dedicate 50% of the time to the following technical tasks:

- Technical support in maintenance and control of the instrumentation used for single-dish observations. - Software development related to this instrumentation - Support in the regular single-dish observations - Support to the PARTNeR program

The rest of the time will be dedicated to science.

Starting date is January 1st 2007. Duration is initially for 1 year and may be extended for another 2 years, depending on performance. Gross salary is apprx. 25000 euros per year.

Applications should include the curriculum vitae, a publication list, a letter stating research interests and two letters of reference.

Applications and informal inquiries should be sent by e-mail before September 15th 2006 to Dra. Olga Suarez (olga@laeff.inta.es) or Dr. Oscar Morata (omorata@laeff.inta.es), or by post to:

Olga Suarez
LAEFF-INTA
Ap. 50727
E-28080 Madrid
Spain

Two Lecturers/Readers in Astronomy Unit of Queen Mary, University of London

Two permanent posts up to Reader level are available in the Astronomy Unit of the School of Mathematical Sciences at Queen Mary, University of London. A UK Lecturer is broadly equivalent to a US Assistant Professor (but permanent), and a Reader to an Associate Professor.

Applicants must have an excellent record of research achievement and have expertise in an area that complements, enhances or extends the current programme of the Unit. Applicants in *Extrasolar Planets and Planet Formation* or Cosmology, are particularly sought, but other areas are very welcome, including observational areas that link to the Unit's theoretical interests. Applicants should also be able to demonstrate a commitment to high quality teaching in the School of Mathematical Sciences, which has buoyant student numbers.

Salary £26,486-£39,093 (Lecturer) to £40,819-£45,984 (Reader) per annum inclusive of London allowance, (with increases pending) depends on qualifications and experience. Interviews will be in September 2006 for the posts to be filled 1 January 2007.

www.maths.qmul.ac.uk/Astronomy describes the Astronomy Unit (13 current permanent faculty, computing facilities include a 156 CPU high performance cluster). Enquiries to: Prof Jim Emerson, Astronomy Unit Director. email: j.p.emerson@qmul.ac.uk; Tel: +44 (0)207 882 5040; Fax +44 (0)208 981 9587. Application pack via www.maths.qmul.ac.uk/about/jobs.shtml

Completed application forms and CVs should be returned via post or email to Mariana Carter, School of Mathematical Sciences, Queen Mary, University of London, Mile End Road, London E1 4NS or email: m.carter@qmul.ac.uk. The closing date is 11th September 2006.

Postdoctoral researcher in star formation

The University of Exeter intends to appoint a post-doctoral researcher in the field of star formation, to work with Tim Harries in the astrophysics group. The successful applicant will conduct research into the circumstellar environment of pre-main sequence (PMS) stars, using a combination of observation and numerical modelling. Applicants with backgrounds in optical and near-IR observations of PMS stars, or radiative-transfer/hydrodynamical modelling are particularly welcome. The research will involve the use of the UK's forefront observational facilities such as the VLT, Gemini, WHT and UKIRT, and numerical simulations will be conducted on our new 1 million euro supercomputer, due for installation in late-2006.

The successful applicant will have an appropriate first degree and a PhD (or equivalent). Salary will be in the range 20,044 to 27,929 pounds pa depending on qualifications and experience. The appointment will be for up to 3.5 years, with an expected start date of 1 September 2006 or as soon as possible thereafter.

An application form is available on request, and applicants should send this, along with a description of their current research and future plans (3 pages), a brief curriculum vitae, and a list of refereed publications to Dr T Harries, School of Physics, University of Exeter, Exeter, EX4 4QL, UK, quoting reference number J44-968. The closing date is 30 June 2006. Please also ensure that 3 letters of reference reach Exeter by this date. Informal enquiries can be made by emailing th@astro.ex.ac.uk.

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.