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Abstracts of recently accepted papers

Lithopanspermia in Star Forming Clusters

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This paper considers the lithopanspermia hypothesis in star forming groups and clusters, where the chances of biological material spreading from one solar system to another is greatly enhanced (relative to action in the field) due to the close proximity of the systems and lower relative velocities. These effects more than compensate for the reduced time spent in such crowded environments. This paper uses $\sim 300,000$ Monte Carlo scattering calculations to determine the cross sections for rocks to be captured by binaries and provides fitting formulae for other applications. We assess the odds of transfer as a function of the ejection speed v_{ej} and number N_* of members in the birth aggregate. The odds of any given ejected meteoroid being recaptured by another solar system are relatively low, about 1 in $10^3 - 10^6$ over the expected range of ejection speeds and cluster sizes. Because the number of ejected rocks (with mass $m > 10$ kg) per system can be large, $N_R \sim 10^{16}$, virtually all solar systems are likely to share rocky ejecta with all of the other solar systems in their birth cluster. The number of ejected rocks that carry living microorganisms is much smaller and less certain, but we estimate that $N_B \sim 10^7$ rocks can be ejected from a biologically active solar system. For typical birth environments, the capture of life bearing rocks is expected to occur approximately 10 – 16,000 times per cluster (under favorable conditions), depending on the ejection speeds. Only a small fraction ($f_{imp} \sim 10^{-4}$) of the captured rocks impact the surfaces of terrestrial planets, so that $N_{ips} \approx 10^{-3} - 1.6$ lithopanspermia events are expected (per cluster). Finally, we discuss the question of internal vs external seeding of clusters and the possibility of Earth seeding young clusters over its biologically active lifetime.

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The Galactic Constants and Rotation Curve from Molecular-Gas Observations

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We received photometric distances and radial velocities for the molecular gas for 270 star formation regions and estimate the distance to the Galactic center from ten tangent points to be $R_0 = 8.01 \pm 0.44$ kpc. Estimates of R_0 derived over the last decade are summarized and discussed; the average value is R_0 is 7.80 ± 0.33 kpc. We analyze deviations from the axial symmetry of gas motion around the Galactic center in the solar neighborhood. Assuming a flat rotation curve we obtain $\Theta_0 = 200 \pm 4$ km/s for the for the circular velocity of the Sun by regions beyond Perseus arm.

Using these galactic constants, we have calculated galactic rotation curve. Virtually along its total extension from the central bar to the periphery, rotation curve is flat. The jump of the velocity in the region of the central bar corotation in the quadrant I is equal to 20 km/s. We derived analytical formulas for the rotation curves of the northern and southern hemispheres of the Galaxy for $R_0 = 8.0$ kpc and $\Theta_0 = 200$ km/s.

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A Mid-Infrared Imaging Survey of Embedded Young Stellar Objects in the ρ Ophiuchi Cloud Core

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Results of a comprehensive, new, ground-based mid-infrared imaging survey of the young stellar population of the ρ Ophiuchi cloud are presented. Data were acquired at the Palomar 5-m and at the Keck 10-m telescopes with the MIRLIN and LWS instruments, at 0.5'' and 0.25'' resolutions, respectively. Of 172 survey objects, 85 were detected. Among the 22 multiple systems observed, 15 were resolved and their individual component fluxes determined. A plot of the frequency distribution of the detected objects with SED spectral slope shows that YSOs spend $\sim 4 \times 10^5$ yr in the Flat Spectrum phase, clearing out their remnant infall envelopes. Mid-infrared variability is found among a significant fraction of the surveyed objects and is found to occur for all SED classes with optically thick disks. Large amplitude near-infrared variability, also found for all SED classes with optically thick disks, seems to occur with somewhat higher frequency at the earlier evolutionary stages. Although a general trend of mid-infrared excess and NIR veiling exists progressing through SED classes, with Class I objects generally exhibiting $r_K \geq 1$, Flat Spectrum objects with $r_K \geq 0.58$, and Class III objects with $r_K = 0$, Class II objects exhibit the widest range of r_K values, ranging from $0 \leq r_K \leq 4.5$. However, the highly variable value of veiling that a single source can exhibit in any of the SED classes in which active disk accretion can take place is striking, and is direct observational evidence for highly time-variable accretion activity in disks. Finally, by comparing mid-infrared vs. near-infrared excesses in a subsample with well-determined effective temperatures and extinction values, disk clearing mechanisms are explored. The results are consistent with disk clearing proceeding from the inside-out.

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Preprints are available from <http://arxiv.org/abs/astro-ph/0504426>

Testing the massive disk scenario for IRAS 18089-1732

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Investigating in more detail the previously suggested massive disk scenario for the High-Mass Protostellar Object IRAS 18089-1732, we observed the source in the 860 μ m band with the Submillimeter Array in various spectral lines and the submm continuum emission at (sub-)arcsecond spatial resolution. Fifty spectral lines from eighteen different species spanning upper level energy states between 17 and 747K were detected. One of the assumed best tracers for massive disks, CH₃CN, is optically thick and does not allow a further disk investigation. However, the complex molecule HCOOCH₃ appears optically thin and exhibits a velocity shift across the central core perpendicular to the emanating outflow. This signature is comparable to well-known low-mass disks and confirms the detection of a massive rotating structure likely associated with the central accretion disk. Assuming equilibrium between centrifugal and gravitational force, the estimated mass for this rotating structure is $16/(\sin^2(i)) M_\odot$ (with i the unknown inclination angle), of the same order as the gas mass derived from the continuum emission. Therefore, in contrast to low-mass disks, a considerable amount of the central gas mass is associated with the rotation, implying that massive disks may not be Keplerian. A temperature estimate based on the CH₃CN(19–18) K-ladder results in ~ 350 K, thus a hot core has already formed in this region. An analysis of the submm continuum emission reveals even at this high spatial resolution only one isolated massive dust core without any detectable companions down to mass limits between 0.2 and $3 M_\odot$ (depending on the assumed temperature). Potential implications for the massive cluster formation are discussed. The radial intensity distribution of the core is highly non-symmetric, outlining the difficulties of density structure investigations based on radial averaging.

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<http://cfa-www.harvard.edu/~hbeuther>

Evolution of the Solar Nebula. VII. Formation and Survival of Protoplanets Formed by Disk Instability

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A major concern for the disk instability mechanism for giant planet formation is survival of the self-gravitating clumps that form in a marginally gravitationally unstable disk. Previous grid-based calculations have found that these clumps may only survive for an orbital period or two, an outcome that has been attributed to insufficient spatial resolution of the clumps. Here we use the highest spatial resolution grid-based models to date (effectively over 8×10^6 grid points, with a locally refined radial grid and 1024 azimuthal grid points) to demonstrate that clump formation and survival is enhanced as the numerical resolution is increased, even with a full treatment of disk thermodynamics and radiative transfer. The overall disk evolution appears to be converging toward a solution with robust spiral arms and self-gravitating protoplanets. The survival of these protoplanets is then further explored by introducing “virtual protoplanets”, point masses representing massive protoplanets that accrete gas from the disk and interact with the disk as they orbit around the protostar. While growing cores and protoplanets formed by core accretion are thought to be subject to significant orbital migration, the virtual protoplanet models show that protoplanets formed by disk instability are likely to avoid rapid inward orbital migration, at least initially, because the self-gravitating disk gas flows inward, past the protoplanets, while the protoplanets orbit relatively undisturbed. Subsequent orbital migration in this case may depend primarily on the outer disk life time and hence on the star-forming environment, i.e., whether it is Taurus-like with relatively long-lived outer disks, or Orion-like with relatively short-lived outer disks. The latter environment should lead to minimal inward orbital migration, as appears to be the case for our Solar System, while the former may lead to sufficient inward migration to produce the observed short-period gas giant planets.

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Preprint available at <http://www.dtm.ciw.edu/boss/ftp/nebulavii/>

On the Identification of High Mass Star Forming Regions using IRAS: Contamination by Low-Mass Protostars

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We present the results of a survey of a small sample (14) of low-mass protostars ($L_{IR} < 10^3 L_{\odot}$) for 6.7 GHz methanol maser emission performed using the ATNF Parkes radio telescope. No new masers were discovered. We find that the lower luminosity limit for maser emission is near $10^3 L_{\odot}$, by comparison of the sources in our sample with previously detected methanol maser sources. We examine the IRAS properties of our sample and compare them with sources previously observed for methanol maser emission, almost all of which satisfy the Wood & Churchwell criterion for selecting candidate UCHII regions. We find that about half of our sample satisfy this criterion, and in addition almost all of this subgroup have integrated fluxes between 25 and 60 μm that are similar to sources with detectable methanol maser emission. By identifying a number of low-mass protostars in this work and from the literature that satisfy the Wood & Churchwell criterion for candidate UCHII regions, we show conclusively for the first time that the fainter flux end of their sample is contaminated by lower-mass non-ionizing sources, confirming the suggestion by van der Walt and Ramesh & Sridharan.

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Faint Fuzzies and the Formation of Lenticular Galaxies

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We investigate the dynamical state of a new class of extended star clusters, known as "Faint Fuzzies", that were discovered in two nearby S0 galaxies, NGC 1023 and NGC 3384. It is shown that the Faint Fuzzies of NGC 1023 lie in a fast rotating ring-like structure within the galactic disk with mean radius of 5 kpc, rotational velocity of 200 km/s and velocity dispersion of 115 km/s. We propose a scenario for the origin of Faint Fuzzies that is connected to the origin of S0 galaxies as a result of galaxy-galaxy interactions in dense environments. As is apparent in the Cartwheel galaxy, and is confirmed by numerical simulations, the passage of a small galaxy through, or close to, the center of a disk galaxy can form a ring of clumpy star formation with a radius comparable to the Faint Fuzzy ring radius in NGC 1023. In this case, the Faint Fuzzies are signposts for the transformation of spiral galaxies into lenticulars via such interactions.

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Crystalline Silicate Emission in the Protostellar Binary Serpens–SVS20

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We present spatially resolved mid-infrared spectroscopy of the class I/flat-spectrum protostellar binary system SVS20 in the Serpens cloud core. The spectra were obtained with the mid-infrared instrument T-ReCS on Gemini-South. SVS20-South, the more luminous of the two sources, exhibits a mid-infrared emission spectrum peaking near 11.3 μm , while SVS20-North exhibits a shallow amorphous silicate absorption spectrum with a peak optical depth of $\tau \sim 0.3$. After removal of the the line-of-sight extinction by the molecular common envelope, the "protostar-only" spectra are found to be dominated by strong amorphous olivine emission peaking near 10 μm . We also find evidence for emission from crystalline forsterite and enstatite associated with both SVS20-S and SVS20-N. The presence of crystalline silicate in such a young binary system indicates that the grain processing found in more evolved HAeBe and T Tauri pre-main sequence stars likely begins at a relatively young evolutionary stage, while mass accretion is still ongoing.

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Chemical differentiation along the CepA-East outflows

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We present the results of a multiline survey at mm-wavelengths of the Cepheus A star forming region. Four main flows have been identified: three pointing in the SW, NE, and SE directions and accelerating high density CS clumps. The fourth outflow, revealed by high-sensitivity HDO observations, is pointing towards South and is associated with conditions particularly favourable to a chemical enrichment. At the CepA-East position the emissions due to the ambient clump and to the outflows coexist and different molecules exhibit different spectral behaviours. Some species ($C^{13}CH$, C_3H_2 , CH_2CO , CH_3C_2H , $HC^{18}O^+$) exhibit relatively narrow lines at ambient velocities (ambient peak). Other molecules (CO , CS , H_2S , SiO , SO , SO_2) show extended wings tracing the whole range of the outflow velocities. Finally, OCS , H_2CS , HDO , and CH_3OH are associated with wings and, in addition, show wings and in addition reveal a bright high velocity redshifted spectral peak (outflow peak) which can be used to investigate the southern outflows. At ambient velocities the gas is dense ($> 10^5 \text{ cm}^{-3}$) and different components at distinct temperatures coexist, ranging from the relatively low kinetic temperatures ($\leq 50 \text{ K}$) measured with H_2S , CH_3OH , H_2CS , and CH_3C_2H , to definitely higher temperature conditions, $\sim 100\text{-}200 \text{ K}$, obtained from the SiO , SO , and SO_2 spectra. For the outflow peak we derive densities between $\sim 10^4 \text{ cm}^{-3}$ to $\sim 10^7 \text{ cm}^{-3}$ and high temperatures, $\simeq 100\text{-}200 \text{ K}$, indicating regions compressed and heated by shocks.

The analysis of the line profiles shows that the SiO molecule dominates at the highest velocities and at the highest excitation conditions, confirming its close association with shocks. H_2S , SO_2 , and SO preferentially trace more quiescent regions than SiO , and in particular a lack of bright H_2S emission at the highest velocities is found. OCS and H_2CS emit at quite high velocities, where the abundances of three shock tracers like SiO , CH_3OH , and HDO are higher. These results may indicate that H_2S is not the only major sulphur carrier in the grain mantles, and that OCS and H_2CS may probably play an important role on the grains; or that alternatively they rapidly form once the mantle is evaporated after the passage of a shock. Finally, the outflow peak emission has been compared with recent time-dependent sulphur chemistry models: the results indicate that, if associated with accurate measurements of the physical conditions, the CH_3OH/H_2CS column density ratio can be used as an effective chemical clock to date the age of shocked gas.

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<http://www.arcetri.astro.it/~codella/cepaii.ps.gz>

On the origin of the HI holes in the interstellar medium of dwarf irregular galaxies

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We suggest that large HI holes observed in the interstellar medium (ISM) of galaxies such as the Large Magellanic Cloud (LMC), the Small Magellanic Cloud (SMC) and Holmberg II (Ho II, DDO 50, UGC 4305) can form as the combined result of turbulence coupled with thermal and gravitational instabilities. We investigate this problem with three dimensional hydrodynamical simulations, taking into account cooling and heating processes and the action of the self-gravity of the gas. We construct an algorithm for radiative transfer to post-process the simulated data and build emission maps in the 21 cm neutral hydrogen line. With this approach, we are able to reproduce the structure of the shells and holes as observed in regions of the ISM, where no stellar activity is detected. In order to quantify the comparison of our synthetic maps to the observations, we calculate the physical scale-autocorrelation length relation ($L - L_{cr}$ relation) both on the synthetic HI maps and the HI map of Ho II. The $L - L_{cr}$ relation shows a linear increase of the autocorrelation length with the physical scale up to the scale of energy injection and flattens for larger scales. The comparison of the $L - L_{cr}$ relation between the observations and the synthetic maps suggests that turbulence is driven in the ISM of Ho II on large scales ($\sim 6 \text{ kpc}$). The slope of the $L - L_{cr}$ relation in the linear regime in Ho II is better reproduced by models where turbulence is coupled with a weak efficiency cooling of the gas. These results demonstrate the importance of the interplay between turbulence and the thermodynamics of the gas for structure formation in the ISM. Our analysis can be used to determine the scale on which kinetic energy is injected in the ISM of dwarf irregular galaxies, and to derive, in a first approximation, the cooling rate of the gas.

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The Physical Natures of Class I and Flat-Spectrum Protostellar Photospheres: A Near-Infrared Spectroscopic Study

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We present high resolution ($R \simeq 18,000$), high signal-to-noise, $2 \mu\text{m}$ spectra of 52 infrared-selected Class I and flat-spectrum young stellar objects in the Taurus-Auriga, ρ Ophiuchi, Serpens, Perseus, and Corona Australis dark clouds. We detect key absorption lines in 41 objects and fit synthetic spectra generated from pre-main sequence models to deduce the effective temperatures, surface gravities, near-infrared veilings, rotation velocities, and radial velocities of each of these 41 sources. We find these objects to span ranges in effective temperature, surface gravity, and stellar luminosity which appear similar to those of late spectral-type Class II sources and classical T-Tauri stars. However, due to significant but uncertain corrections for scattering and extinction, the derived luminosities for the embedded protostellar objects must be regarded as being highly uncertain. We determine that the mean $2 \mu\text{m}$ veiling of Class I and flat-spectrum objects is significantly higher than that of Class II objects in the same region where both types of objects are extensively observed (ρ Oph). We find a significant fraction of our protostellar sample also exhibits emission lines. Twenty-three objects show H_2 emission, usually indicative of the presence of energetic outflows. Thirty-four sources show HI Br γ emission and a number of these exhibit profile asymmetries consistent with in-fall. Eight sources show significant $\Delta v = 2$ CO emission suggestive of emission from a circumstellar disk. Overall, these observations indicate that Class I and flat-spectrum objects are self-embedded protostars undergoing significant mass accretion, although the objects appear to span a broad range of mass accretion activity.

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The circumstellar environment of T Tau S at high spatial and spectral resolution

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We have obtained the first high spatial ($0.05''$) and spectral ($R \sim 35000$) resolution $2 \mu\text{m}$ spectrum of the T Tau S tight binary system using adaptive optics on the Keck II telescope. We have also obtained the first 3.8 and $4.7 \mu\text{m}$ images that resolve the three components of the T Tau multiple system, as well as new 1.6 and $2.2 \mu\text{m}$ images. Together with its very red near-infrared colors, the spectrum of T Tau Sb shows that this T Tauri star is extinguished by a roughly constant extinction of $A_V \sim 15$ mag, which is probably the $0.7'' \times 0.5''$ circumbinary structure recently observed in absorption in the ultraviolet. T Tau Sa, which is also observed through this screen and is actively accreting, further possesses a small edge-on disk that is evidenced by warm (390 K), narrow overtone CO rovibrational absorption features in our spectrum. We find that T Tau Sa is most likely an intermediate-mass star surrounded by a semi-transparent 2 – 3 AU-radius disk whose asymmetries and short Keplerian rotation explain the large photometric variability of the source on relatively short timescales. We also show that molecular hydrogen emission exclusively arises from the gas that surrounds T Tau S and that its spatial and kinematic structure, while providing suggestive evidence for a jet-like structure, is highly complex.

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A Hot Wind from the Classical T Tauri Stars: TW Hydrae and T Tauri

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Spectroscopy of the infrared He I ($\lambda 10830$) line with KECK/NIRSPEC and IRTF/CSHELL and of the ultraviolet C III ($\lambda 977$) and O VI ($\lambda 1032$) emission with FUSE reveals that the classical T Tauri star TW Hydrae exhibits P Cygni profiles, line asymmetries, and absorption indicative of a continuous, fast (~ 400 km/s), hot ($\sim 300,000$ K) accelerating outflow with a mass loss rate $\sim 10^{-11}$ – $10^{-12} M_{\odot} \text{ yr}^{-1}$ or larger. Spectra of T Tauri N appear consistent with such a wind. The source of the emission and outflow seems restricted to the stars themselves. Although the mass accretion rate is an order of magnitude less for TW Hya than for T Tau, the outflow reaches higher velocities at chromospheric temperatures in TW Hya. Winds from young stellar objects may be substantially hotter and faster than previously thought.

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Chandra HETGS Multi-phase Spectroscopy of the Young Magnetic O Star θ^1 Orionis C

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We report on four *Chandra* grating observations of the oblique magnetic rotator θ^1 Ori C (O5.5 V) covering a wide range of viewing angles with respect to the star's 1060 G dipole magnetic field. We employ line-width and centroid analyses to study the dynamics of the X-ray emitting plasma in the circumstellar environment, as well as line-ratio diagnostics to constrain the spatial location, and global spectral modeling to constrain the temperature distribution and abundances of the very hot plasma. We investigate these diagnostics as a function of viewing angle and analyze them in conjunction with new MHD simulations of the magnetically channeled wind shock mechanism on θ^1 Ori C. This model fits all the data surprisingly well, predicting the temperature, luminosity, and occultation of the X-ray emitting plasma with rotation phase.

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<http://shayol.bartol.udel.edu/rhdt/t1oc>

The Molecular Condensations Ahead of Herbig-Haro Objects. III. Radiative and dynamical perturbations of the HH 2 condensation

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We have carried out an extensive observational study (from BIMA data) and made a preliminary theoretical investigation of the molecular gas around HH 2. The molecular maps show a very complex morphological, kinematical and chemical structure. For clarity we divided the observed region in four subregions: (1) The Ahead Core, located ahead of HH 2: its chemistry may be a consequence of a weak UV field originating in HH 2. The chemical structure within the Ahead Core suggests that it is not homogeneous but probably composed of small clumps; (2) The SO₂ Clump, which is a molecular component within the Ahead Core that is more exposed to the UV radiation from HH 2. An increase of density and relative molecular abundances is observed towards HH 2. The UV radiation is possibly the source of molecular enhancement. Our chemical analysis confirms that this clump must have substructure within it; (3) the West Core, which is surrounded by a ring structure of shocked ionized gas and mid-IR emission. The ring structure is likely a consequence of the fact that the core is in the foreground with respect to the shocked and hot component. The chemistry of this core can be best explained as arising from a combination of an old photo-processed dense clump and a PDR, with or without a warm interface created in the interaction of the outflow with the core; (4) The High Velocity Region, associated with HH 2, is traced by HCO⁺ but not by other molecular shock tracers. The chemistry can be accounted for by the interaction of the VLA 1 outflow with a dense clump *via* non-dissociative shocks and by the presence of a very strong UV field. The overall main conclusion of this work confirms the findings of Paper I and II, by demonstrating that in addition to the strong photochemical effects caused by penetration of the UV photons from HH 2 into molecular cloud, a range of complex radiative and dynamical interactions occur. Thus, despite the apparent ‘quiescent’ nature of the molecular cloud ahead of HH 2, the kinematical properties observed within the field of view suggest that it is possibly being driven out by the powerful winds from the VLA 1 protostar.

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IX Ophiuchi: A High-Velocity Star near a Molecular Cloud

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The molecular cloud Barnard 59 is probably an outlier of the Upper Sco/ ρ Oph complex. B59 contains several T Tauri stars (TTS), but outside its northwestern edge are three other emission-H α objects whose nature has been unclear: IX, KK, and V359 Oph. This paper is a discussion of all three and of a nearby Be star (HD 154851), based largely on Keck/HIRES spectrograms obtained in 2004. KK Oph is a close (1.6 arcsec) double. The brighter component is a HAeBe star; the fainter a K-type TTS. The complex BVR variations of the unresolved pair require both components to be variable. V359 Oph is a conventional TTS. Thus these pre-main-sequence stars continue to be recognizable as such well outside the boundary of their parent cloud. IX Oph is quite different. Its absorption spectrum is about type G, with many peculiarities: all lines are narrow, but abnormally weak, with structures that depend on ion and excitation level, and that vary in detail from month to month. It could be a spectroscopic binary of small amplitude. H α and H β are the only prominent emission lines. They are broad, with variable central reversals. However, the most unusual characteristic of IX Oph is the very high (heliocentric) radial velocity: about -310 km s⁻¹, common to all spectrograms, and very different from the radial velocity of B59, about -7 km s⁻¹. There is no detectable Li I $\lambda 6707$ line. There is reason to believe that IX Oph is actually a background object, only aligned with B59. Several conceivable interpretations are discussed: (1) It is unlikely that it is a high-velocity ejectee from the Upper Sco or Upper Cen-Lup associations (the lack of detectable $\lambda 6707$ shows it is not the product of a very recent event, and the proper motion points in the wrong direction); or that it was born in, or ejected from one of the distant high-velocity CO clouds at this longitude ($l = 357^\circ$). (2) A stronger possibility is that it is simply a metal-poor high-velocity G- or K-type giant (but such stars are not irregularly variable in light and do not have such strong Balmer emission lines). More likely, (3) IX Oph is a member of the high-velocity low-metallicity SRd class of semiregular variables found in the field and in some globular clusters. At some phases, those stars show H α emission like that found in IX Oph, and in one example, emission lines of neutral metals and double absorption lines as in IX Oph.

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The loopy ultraviolet line profiles of RU Lupi: accretion, outflows, and fluorescence

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We present far-ultraviolet spectra of the classical T Tauri star RU Lupi covering the 912–1710 Å spectral range, as observed by HST/STIS and FUSE. We use these spectra, which are rich in emission and absorption lines, to probe both the accreting and outflowing gas. Absorption in the Ly α profile constrains the extinction to $A_V \sim 0.07$ mag, which we confirm with other diagnostics. We estimate a mass accretion rate of $(5 \pm 2) \times 10^{-8} M_{\odot} \text{ yr}^{-1}$ using the optical-NUV accretion continuum. The accreting gas is also detected in bright, broad lines of C IV, Si IV, and N V, which all show complex structures across the line profile. Many other emission lines, including those of H₂ and Fe II, are pumped by Ly α . RU Lupi's spectrum varies significantly in the FUV; our STIS observations occurred when RU Lupi was brighter than several other observations in the FUV, possibly due to a high mass accretion rate.

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The initial conditions of isolated star formation - VI. SCUBA mapping of prestellar cores

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Observations have been carried out with the submillimetre common-user bolometer array (SCUBA) at the James Clerk Maxwell Telescope (JCMT) of regions of comparatively isolated star formation in molecular cloud cores. 52 starless cores were observed, which are molecular cloud cores that do not contain any sign of protostellar activity such as infrared sources or bipolar outflows. These are all therefore candidate prestellar cores, which are believed to represent the stage of star formation that precedes the formation of a protostar. 29 of the 52 cores were detected at 850 microns at varying levels of signal-to-noise ratio greater than 3-sigma at peak, while 23 of the cores were observed but not detected. The mean detection lower limit of the data corresponds roughly to an A_V of order 15 under typical assumptions. The detected cores were split into 'bright' cores and 'intermediate' cores, depending on their peak flux density at 850 microns. Those with peak 850-micron flux densities greater than 170 mJy/beam were designated 'bright' cores. Those with peak 850-micron flux densities less than this value were designated 'intermediate' cores. This dividing line corresponds to a mean detection limit of 10-sigma at peak, and an approximate A_V of 50 under typical assumptions. 13 of the 29 detected cores are found to be bright and 16 are intermediate. The data are combined with our previously published ISO data, and the physical parameters of the cores, such as density and temperature, are calculated. The bright cores are detected with sufficiently high signal-to-noise ratio to allow their structure to be mapped. Radial flux density profiles of these show flattened inner regions and sharp boundaries, consistent with previous observations of prestellar cores. Detailed fitting of the bright core radial profiles shows that they are not critical Bonnor-Ebert spheres, in agreement with previous findings. However, we find that intermediate cores, such as B68 (which has previously been claimed to be a Bonnor-Ebert sphere), may in fact be consistent with the Bonnor-Ebert criterion, suggesting perhaps that cores pass through such a phase during their evolution. We also find that the masses of the bright cores have a mean value of approximately the same order as their virial masses. We make rough estimates of core lifetimes based on the statistics of detections and find that the lifetime of a prestellar

core is roughly $\sim 3 \times 10^5$ years, while that of a bright core is $\sim 1.5 \times 10^5$ years. Comparisons with some models that regulate collapse using either magnetic fields or turbulence show that no model can match all of the data. Models that are tuned to fit the total prestellar core lifetime, do not predict the relative numbers of cores seen at each stage.

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A General Theory of Turbulence-Regulated Star Formation, From Spirals to ULIRGs

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We derive an analytic prediction for the star formation rate in environments ranging from normal galactic disks to starbursts and ULIRGs in terms of the observables of those systems. Our calculation is based on three premises: (1) star formation occurs in virialized molecular clouds that are supersonically turbulent; (2) the density distribution within these clouds is lognormal, as expected for supersonic isothermal turbulence; (3) stars form in any sub-region of a cloud that is so overdense that its gravitational potential energy exceeds the energy in turbulent motions. We show that a theory based on this model is consistent with simulations and with the observed star formation rate in the Milky Way. We use our theory to derive the Kennicutt-Schmidt Law from first principles, and make other predictions that can be tested by future observations. We also provide an algorithm for estimating the star formation rate that is suitable for inclusion in numerical simulations.

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Hot Cores : Probes of High Redshift Galaxies?

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The very high rates of second generation star formation detected and inferred in high redshift objects should be accompanied by intense millimetre-wave emission from hot core molecules. We calculate the molecular abundances likely to arise in hot cores associated with massive star formation at high redshift, using several different models of metallicity in the early Universe. If the number of hot cores exceeds that in the Milky Way Galaxy by a factor of at least one thousand, then a wide range of molecules in high redshift hot cores should have detectable emission. It should be possible to distinguish between different models for the production of metals and hence hot core molecules should be useful probes of star formation at high redshift.

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A deep survey of brown dwarfs in Orion with Gemini

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We report the results of a deep near infrared (JHK) survey of the outer parts of the Trapezium Cluster with Gemini South/Flamingos. 396 sources were detected in a 26 arcmin² area, including 138 brown dwarf candidates, defined as $M < 0.075 M_{\odot}$ for an assumed age of 1 Myr. Only 33 of the brown dwarf candidates are planetary mass candidates

(PMCs) with estimated masses in the range $0.003 < M < 0.012 M_{\odot}$. In an extinction limited sample ($A_V < 5$) complete to approximately $0.005 M_{\odot}$ ($5 M_{Jup}$) the mass function appears to drop by a factor of 2 at the deuterium burning threshold, i.e. at planetary masses. After allowing for background contamination it is likely that planetary mass objects at 3-13 M_{Jup} number $< 10\%$ of the cluster population, with an upper limit of 13%. Analysis of the spatial distribution of stars and brown dwarf candidates suggests that brown dwarfs and very low mass stars ($M < 0.1 M_{\odot}$) are less likely than more massive stars to have wide (> 150 AU) binary companions. This result has modest statistical significance (96%) in our data but is supported at 93% confidence by analysis of a completely independent sample taken from the Subaru data of Kaifu et al.(2000). There is a statistically very significant excess of both stars and brown dwarfs with small separations from each other (< 6 arcsec or 2600 AU). This appears to be due to the presence of small N subgroups, which are likely to be dynamically unstable in the long term. Hence these results are consistent with the 'ejected stellar embryo' hypothesis for brown dwarf formation (Reipurth & Clarke 2001). We also report the discovery of two new bipolar nebulae, which are interpreted as Class I protostars.

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L-band ($3.5 \mu\text{m}$) IR-excess in massive star formation, I. 30 Doradus

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L-band data of 30 Doradus at $3.5 \mu\text{m}$ taken with SPIREX (South Pole Infrared Explorer) is presented. The photometry was combined with 2MASS JHK data at $1.25\text{-}2.2 \mu\text{m}$. Colour-colour and colour-magnitude diagrams are constructed and used to determine the sources with infrared excess. These are interpreted as circumstellar disks, and enable the fraction of sources with disks (the cluster disk fraction or CDF) to be determined. We find that $\sim 42\%$ of the sources detected at L-band in 30 Doradus have an IR-excess.

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Protostellar Disks: Formation, Fragmentation, and the Brown Dwarf Desert

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We argue that gravitational instability of typical protostellar disks is not a viable mechanism for the fragmentation into multiple systems – binary stars, brown dwarf companions, or gas giant planets – except at periods above roughly 20,000 years. Our conclusion is based on a comparison between prior numerical work on disk self-gravity by Gammie (2001) with our own analytical models for the dynamical and thermal state of protostellar disks. For this purpose we first develop a simple theory for the initial conditions of low-mass star formation, accounting for the effect of turbulence on the characteristic mass, accretion rate, and angular momentum of collapsing cores. We also present formulae for the probability distribution of these quantities for the case of homogenous Gaussian turbulence. However, our conclusions are not sensitive to this parameterization.

Second, we examine the criterion for fragmentation to occur during star formation, concentrating on the self-gravitational instabilities of protostellar accretion disks in their main accretion phase. Self-gravitational instabilities are strongly dependent on the thermal state of the disk, and we find that the combination of viscous heating and stellar irradiation quenches fragmentation due to Toomre's local instability. Simulations by Matsumoto and Hanawa (2003), which do not include detailed thermal evolution, predict fragmentation in an early phase of collapse. But, fragments born in this phase are on tight orbits and are likely to merge later due to disk accretion. Global instability of the disk may be required to process mass supply, but this is also unlikely to produce fragments. We conclude that numerical

simulations which predict brown dwarf formation by disk fragmentation, but which do not account for irradiation, are unrealistic. Our findings help to explain the dearth of substellar companions to stellar type stars: the brown dwarf desert.

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Giant Planet Migration through the action of Disk Torques and Planet Scattering

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This paper presents a parametric study of giant planet migration through the combined action of disk torques and planet-planet scattering. The torques exerted on planets during Type II migration in circumstellar disks readily decrease the semi-major axes, whereas scattering between planets increases the orbital eccentricities. This paper presents a parametric exploration of the possible parameter space for this migration scenario using two (initial) planetary mass distributions and a range of values for the time scale of eccentricity damping (due to the disk). For each class of systems, many realizations of the simulations are performed in order to determine the distributions of the resulting orbital elements of the surviving planets; this paper presents the results of 8500 numerical experiments. Our goal is to study the physics of this particular migration mechanism and to test it against observations of extrasolar planets. The action of disk torques and planet-planet scattering results in a distribution of final orbital elements that fills the a-e plane, in rough agreement with the orbital elements of observed extrasolar planets. In addition to specifying the orbital elements, we characterize this migration mechanism by finding the percentages of ejected and accreted planets, the number of collisions, the dependence of outcomes on planetary masses, the time spent in 2:1 and 3:1 resonances, and the effects of the planetary IMF. We also determine the distribution of inclination angles of surviving planets and the distribution of ejection speeds for exiled planets.

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Evidence for a co-moving sub-stellar companion of GQ Lup

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We present a companion of the ≤ 2 Myr young classical T Tauri star GQ Lup in the Lupus star forming region at 140 ± 50 pc from imaging, astrometry, and spectroscopy. With direct K-band imaging using VLT/NACO, we detected an object 6 mag fainter than GQ Lup located $0.7''$ west of it. Compared to images obtained 2 to 5 years earlier with Subaru/CIAO and HST/PC, this object shares the proper motion of GQ Lup by 5 and 7σ , respectively, hence it is a co-moving companion. Its $K - L'$ color is consistent with a spectral type early to mid L. Our NACO K-band spectrum yields spectral type M9-L4 with H₂O and CO absorption, consistent with the new GAIA-Dusty template spectrum for $\log g \simeq 2$ to 3 and $T_{\text{eff}} \simeq 2000$ K with $\sim 2 R_{\text{Jup}}$ radius at ~ 140 pc, hence few Jupiter masses. Using the theoretical models from Wuchterl & Tscharnuter (2003), Burrows et al. (1997), and Baraffe et al. (2002), the mass lies between 1 and 42 Jupiter masses.

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Molecular hydrogen emission from protoplanetary disks

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We have modeled self-consistently the density and temperature profiles of gas and dust in protoplanetary disks, taking into account irradiation from a central star. Making use of this physical structure, we have calculated the level populations of molecular hydrogen and the line emission from the disks. As a result, we can reproduce the observed strong line spectra of molecular hydrogen from protoplanetary disks, both in the ultraviolet (UV) and the near-infrared, but only if the central star has a strong UV excess radiation.

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The Modelling of InfraRed Dark Clouds

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This paper presents results from modelling 450 μm and 850 μm continuum and HCO^+ line observations of three distinct cores of an infrared dark cloud (IRDC) directed toward the W51 GMC. In the sub-mm continuum these cores appear as bright, isolated emission features. One of them coincides with the peak of 8.3 μm extinction as measured by the Midcourse Space Experiment satellite. Detailed radiative transfer codes are applied to constrain the cores' physical conditions to address the key question: Do these IRDC-cores harbour luminous sources? The results of the continuum model, expressed in the χ^2 quality-of-fit parameter, are also constrained by the absence of 100 μm emission from IRAS. For the sub-mm emission peaks this shows that sources of 300 solar luminosities are embedded within the cores. For the extinction peak, the combination of continuum and HCO^+ line modelling indicates that a heating source is present as well. Furthermore, the line model provides constraints on the clumpiness of the medium. All three cores have similar masses of about 70-150 solar masses and similar density structures. The extinction peak differs from the other two cores by hosting a much weaker heating source, and the sub-mm emission core at the edge of the IRDC deviates from the other cores by a higher internal clumpiness.

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Age spreads in star forming regions: The lithium test in the Orion Nebula Cluster

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We present the initial results of a study of the surface lithium abundance in a sample of low-mass members ($M_* \sim 0.4\text{--}1.0 M_\odot$) of the Orion Nebula Cluster (ONC) that provide an independent clock to estimate stellar ages. We report discovery of significant depletion of lithium in four stars with estimated mass of $\sim 0.4 M_\odot$ and age ~ 10 Myr. Comparison with the predictions of numerical and analytical models shows excellent agreement between the isochronal age and lithium depletion time scale for two objects, the first case in lithium-poor pre-main sequence stars. Our results bear on the issue of the real age spread in the ONC and hence on the overall duration of the star formation process, indicating that the stellar population did not come into existence in a single, rapid burst.

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Parameter Study of Star-Discs Encounters

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Interactions between disc-surrounded stars might play a vital role in the formation of planetary systems. Here a first parameter study of the effects of encounters on low-mass discs is presented. The dependence of the mass and angular momentum transport on the periastron distance, the relative mass of the encountering stars and eccentricity of the encounter is investigated in detail. This is done for prograde and retrograde coplanar encounters as well as non-coplanar encounters. For distant coplanar encounters our simulation results agree with the analytical approximation of the angular momentum loss by Ostriker(1994). However, for close or high-mass encounters, significant differences to this approximation are found. This is especially so in the case of retrograde encounters, where the analytical result predict no angular momentum loss regardless of the periastron distance whereas the simulations find up to $\sim 20\%$ loss for close encounters. For the non-coplanar case a more complex dependency on the inclination between orbital path and disc plane is found than for distant encounters. For the coplanar prograde case new fitting formulae for the mass and angular momentum loss are obtained, which cover the whole range from grazing to distant encounters. In addition, the final disc size and the mass exchange between discs is examined, demonstrating that for equal mass stars in encounters as close as 1.5 the disc radius, the disc size only is reduced by approximately 10%.

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Disc-Disc Encounters between Low-Mass Protoplanetary Accretion Discs

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Simulations of the collapse and fragmentation of turbulent molecular clouds and dense young clusters show that encounters between disc-surrounded stars are relatively common events which should significantly influence the resulting disc structure. In turn this should alter the accretion rate of disc matter onto the star and the conditions under which planet formation occurs. Although the effects of star-disc encounters have been previously investigated, very little is known about encounters where both stars are surrounded by discs. In this paper encounters of such disc-disc systems are studied quantitatively. It is found that for low-mass discs ($M_D = 0.01 M_{sun}$) the results from star-disc encounters can be straightforwardly generalized to disc-disc encounters as long as there is no mass transport between the discs. Differences to star-disc encounters occur naturally where significant amounts of matter are transported between the discs. In this case it is found that although the mass distribution does not change significantly, matter caught onto highly eccentric orbits is transported surprisingly far inside the disc. The captured mass partly replenishes the disc, but has a much lower angular momentum. This can lead to a reduction of the angular momentum in the entire disc and thus considerably increased accretion shortly after the encounter as well as in the long term.

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Multiplicity Survey of the ρ Ophiuchi Molecular Clouds

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We present a volume-limited multiplicity survey with magnitude cutoff ($m_K \leq 10.5$ mag) of 158 young stellar objects located within or in the vicinity of the ρ Ophiuchi Dark Cloud. With exception of eleven already well observed objects,

all sources have been observed by us in the K-band with 3.5 m telescopes by using speckle techniques. The separation range covered by our survey is $0.13'' \leq \theta \leq 6.4''$, where the lower limit is given by the diffraction limit of the telescopes and the upper limit by confusion with background stars. The multiplicity survey is complete for flux ratios ≥ 0.1 ($\Delta m_K \leq 2.5$) at the diffraction limit. After taking the background density into account the degree of multiplicity is $29.1\% \pm 4.3\%$ and thus only marginally higher than the value $23.5\% \pm 4.8\%$ derived for the given separation range for the main-sequence solar-like stars in the solar neighbourhood (Duquennoy & Mayor 1991). We discuss the implications of these findings.

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Fabry-Perot Observations of HH 1-2

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We present new H α Fabry-Perot observations of the HH 1/2 system. Line profiles, barycenter radial velocity maps and dispersion maps are derived from the channel maps of HH 1 and HH 2. The radial velocity barycenter maps of both HH 1 and HH 2 show a general trend of “red-shifted upstream/blue-shifted downstream” pattern. A “direct+scattered” component model for three emitting condensations is qualitatively successful at reproducing the general features of the barycenter and the velocity dispersion of HH 2.

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Magnetorotational instability in protoplanetary discs

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We investigate the linear growth and vertical structure of the magnetorotational instability (MRI) in weakly ionised, stratified accretion discs. The magnetic field is initially vertical and dust grains are assumed to have settled towards the midplane, so charges are carried by electrons and ions only. Solutions are obtained at representative radial locations from the central protostar for different choices of the initial magnetic field strength, sources of ionisation, disc structure and configuration of the conductivity tensor.

The MRI is active over a wide range of magnetic field strengths and fluid conditions in low conductivity discs. Moreover, no evidence was found of a low-limit field strength below which unstable modes do not exist. For the minimum-mass solar nebula model, incorporating cosmic ray ionisation, perturbations grow at 1AU for $B \leq 8$ G. For a significant subset of these strengths ($200 \text{ mG} \leq B \leq 5 \text{ G}$), the maximum growth rate is of order the ideal MHD rate (0.75Ω). Hall conductivity modifies the structure and growth rate of global unstable modes at 1 AU for all magnetic field strengths that support MRI. As a result, at this radius, modes obtained with a full conductivity tensor grow faster and are active over a more extended cross-section of the disc, than perturbations in the ambipolar diffusion limit. For relatively strong fields (e.g. $B \geq 200 \text{ mG}$), ambipolar diffusion alters the envelope shapes of the unstable modes, which peak at an intermediate height, instead of being mostly flat as modes in the Hall limit are in this region of parameter space. Similarly, when cosmic rays are assumed to be excluded from the disc by the winds emitted by the magnetically active protostar, unstable modes grow at this radius for $B \leq 2$ G. For strong fields, perturbations exhibit a kink at the height where x-ray ionisation becomes active. Finally, for $R = 5 \text{ AU}$ (10 AU), unstable modes exist for $B \leq 800 \text{ mG}$ ($B \leq 250 \text{ mG}$) and the maximum growth rate is close to the ideal-MHD rate for $20 \text{ mG} \leq B \leq 500 \text{ mG}$

($2 \text{ mG} \leq B \leq 50 \text{ mG}$). Similarly, perturbations incorporating Hall conductivity have a higher wavenumber and grow faster than solutions in the ambipolar diffusion limit for $B \leq 100 \text{ mG}$ ($B \leq 10 \text{ mG}$). Unstable modes grow even at the midplane for $B \geq 100 \text{ mG}$ ($B \sim 1 \text{ mG}$), but for weaker fields, a small dead region exists.

This study shows that, despite the low magnetic coupling, the magnetic field is dynamically important for a large range of fluid conditions and field strengths in protostellar discs. An example of such magnetic activity is the generation of MRI unstable modes, which are supported at 1 AU for field strengths up to a few gauss. Hall diffusion largely determines the structure and growth rate of these perturbations for all studied radii. At radii of order 1 AU, in particular, it is crucial to incorporate the full conductivity tensor in the analysis of this instability, and more generally in studies of the dynamics of astrophysical discs.

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Modeling the Physical Structure of the Low Density Pre-protostellar Core Lynds 1498

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Pre-protostellar cores likely represent the incipient stages of low-mass ($\approx 1M_{\odot}$) star formation. Lynds 1498 is a pre-protostellar core (PPC) and was one of the initial objects toward which molecular depletion and differentiation was detected. Despite the considerable scrutiny of L1498, there has not been an extensive study of the density and temperature structure as derived from radiative transfer modeling of dust continuum observations. We present deep SCUBA observations of L1498 at 850 and 450 μm , high resolution BEARS maps of the N_2H^+ $1 \rightarrow 0$ transition, CSO observations of the N_2H^+ $3 \rightarrow 2$ transition, and GBT observations of the C_3S $4 \rightarrow 3$ transition. We also present a comparison of derived properties between L1498 and nearby PPCs that have been observed at far-infrared and submillimeter wavelengths. The L1498 continuum emission is modeled using a one-dimensional radiative transfer code that self-consistently calculates the temperature distribution and calculates the SED and intensity profiles at 850 and 450 μm . We present a more realistic treatment of PPC heating which varies the strength of the ISRF, s_{isrf} , and includes attenuation of the ISRF due to dust grains at the outer radius of the core, A_V . The best-fitted model consists of a Bonner-Ebert sphere with a central density of $1 - 3 \times 10^4 \text{ cm}^{-3}$, $R_o \approx 0.29 \text{ pc}$, $0.5 \leq s_{\text{isrf}} \leq 1$, $A_V \approx 1 \text{ mag}$, and a nearly isothermal temperature profile of $\approx 10.5 \text{ K}$ for OH8 opacities. C_3S emission shows a central depletion hole while N_2H^+ emission is centrally peaked. We derive a mean N_2H^+ abundance of 4.0×10^{-10} relative to H_2 that is consistent with chemical models for a dynamically young yet chemically evolved source. The observed depletions of C_3S and H_2CO , the modest N_2H^+ abundance, and a central density that is an order of magnitude lower than other modeled PPCs suggests that L1498 may be a forming PPC. Our derived temperature and density profile will improve modeling of molecular line observations that will explicate the core's kinematical and chemical state.

Accepted by ApJ

Paper may be downloaded from <http://www.aoc.nrao.edu/~yshirley/Publications/msl1498.ps>

Chandra X-ray Observations of the Young Stellar Cluster NGC 6193 in the Ara OB1 Association

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A 90 ksec *Chandra* HETG observation of the young stellar cluster NGC 6193 in the southern Ara OB1 association detected 43 X-ray sources in a $2' \times 2'$ core region centered on the massive O stars HD 150135 (O6.5V) and HD 150136 (O3 + O6V). The cluster is dominated by exceptionally bright X-ray emission from the two O stars, which are separated by only $10''$. The X-ray luminosity of HD 150136 is $\log L_X = 33.39$ (ergs s⁻¹), making it one of the most luminous O-star X-ray sources known. All of the fainter X-ray sources in the core region have near-IR counterparts, but existing JHK photometry provides little evidence for near-IR excesses. These core sources have typical mean photon energies $\langle E \rangle \approx 2$ keV and about one-third are variable. It is likely that some are young low-mass stars in the cluster, but cluster membership remains to be determined. Grating spectra show that the X-ray properties of HD 150135 and HD 150136 are similar, but not identical. Both have moderately broadened unshifted emission lines and their emission is dominated by cool plasma at $kT \approx 0.3$ keV, pointing to a wind-shock origin. However, the emission of HD 150136 is slightly hotter and four times more luminous than its optical twin HD 150135. We discuss the possibility that a radiative colliding wind shock contributes to the prodigious X-ray output of the short-period (2.66 d) spectroscopic binary HD 150136. A surprising result is that the X-ray emission of HD 150136 is slowly variable on a timescale of <1 day. The origin of the variability is not yet known but the observed behavior suggests that it is an occultation effect.

Accepted by MNRAS

Preprints are available at <http://arxiv.org/abs/astro-ph/0504559>

How to identify the youngest protostars

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We study the transition from a prestellar core to a Class 0 protostar, using SPH to simulate the dynamical evolution, and a Monte Carlo radiative transfer code to generate the SED and isophotal maps. For a prestellar core illuminated by the standard interstellar radiation field, the luminosity is low and the SED peaks at $\sim 190 \mu\text{m}$. Once a protostar has formed, the luminosity rises (due to a growing contribution from accretion onto the protostar) and the peak of the SED shifts to shorter wavelengths (80 to $100 \mu\text{m}$). However, by the end of the Class 0 phase, the accretion rate is falling, the luminosity has decreased, and the peak of the SED shifts back towards longer wavelengths (90 to $150 \mu\text{m}$). In our simulations, the density of material around the protostar remains sufficiently high well into the Class 0 phase that the protostar only becomes visible in the NIR if it is displaced from the centre dynamically. Raw submm/mm maps of Class 0 protostars tend to be much more centrally condensed than those of prestellar cores. However, when convolved with a typical telescope beam, the difference in central concentration is less marked, although the Class 0 protostars appear more circular. Our results suggest that, if a core is deemed to be prestellar on the basis of having no associated IRAS source, no cm radio emission, and no outflow, but it has a circular appearance and an SED which peaks at wavelengths below $\sim 170 \mu\text{m}$, it may well contain a very young Class 0 protostar.

Accepted by Astronomy & Astrophysics

<http://www.astro.cf.ac.uk/pub/Dimitrios.Stamatellos/publications>

Line profiles of molecular ions toward the pre-stellar core LDN 1544

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Velocity profiles of ground state lines of H_2D^+ , HC^{18}O^+ and N_2H^+ , observed previously with the CSO and IRAM 30m telescopes, are modeled with a Monte Carlo radiative transfer program to study the temperature, density and velocity structure of the pre-stellar core LDN 1544. The H_2D^+ line is double-peaked like that of the other ions, but previous models that fit the HC^{18}O^+ and N_2H^+ profiles are found not to fit the H_2D^+ data. Matching the H_2D^+ observations requires at least three modifications to the model at small radii: (1) the density profile must continue to rise inward and not flatten off toward the center; (2) the gas temperature must be nearly constant and not drop inwards significantly; (3) the infall velocity must increase inward, in a fashion intermediate between ‘quasi-static’ (ambipolar diffusion) and ‘fully dynamic’ (Larson-Penston) collapse. The C^{18}O emission indicates a chemical age of $\lesssim 0.1$ Myr. The effects of a flattened structure and rotation on the line profiles are shown to be unimportant, at least on the scales probed by single-dish telescopes. Alternatively, the H_2D^+ profile is affected by absorption in the outer layers of the core, if gas motions in these layers are sufficiently small.

Accepted by A&A

<http://www.arXiv.org/abs/astro-ph/0505072>

The variation of integrated star IMFs among galaxies

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The integrated galaxial initial mass function (IGIMF) is the relevant distribution function containing the information on the distribution of stellar remnants, the number of supernovae and the chemical enrichment history of a galaxy. Since most stars form in embedded star clusters with different masses the IGIMF becomes an integral of the assumed (universal or invariant) stellar IMF over the embedded star-cluster mass function (ECMF). For a range of reasonable assumptions about the IMF and the ECMF we find the IGIMF to be steeper (containing fewer massive stars per star) than the stellar IMF, but below a few M_\odot it is invariant and identical to the stellar IMF for all galaxies. However, the steepening sensitively depends on the form of the ECMF in the low-mass regime. Furthermore, observations indicate a relation between the star formation rate of a galaxy and the most massive young stellar cluster in it. The assumption that this cluster mass marks the upper end of a young-cluster mass function leads to a connection of the star formation rate and the slope of the IGIMF above a few M_\odot . The IGIMF varies with the star formation history of a galaxy. Notably, large variations of the IGIMF are evident for dE, dIrr and LSB galaxies with a small to modest stellar mass. We find that for any galaxy the number of supernovae per star (NSNS) is suppressed relative to that expected for a Salpeter IMF. Dwarf galaxies have a smaller NSNS compared to massive galaxies. For dwarf galaxies the NSNS varies substantially depending on the galaxy assembly history and the assumptions made about the low-mass end of the ECMF. The findings presented here may be of some consequence for the cosmological evolution of the number of supernovae per low-mass star and the chemical enrichment of galaxies of different mass.

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<http://arxiv.org/pdf/astro-ph/0502525>

The Spitzer c2d Survey of Large, Nearby, Interstellar Clouds. I. Chamaeleon II Observed with MIPS

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We present maps of over 1.5 square degrees in Chamaeleon (Cha) II at 24, 70, and 160 micron observed with the Spitzer Space Telescope Multiband Imaging Photometer for Spitzer (MIPS) and a 1.2 square degree millimeter map from SIMBA on the Swedish-ESO Submillimetre Telescope (SEST). The c2d Spitzer Legacy Team's data reduction pipeline is described in detail. Over 1500 24 micron sources and 41 70 micron sources were detected by MIPS with fluxes greater than $10\text{-}\sigma$. More than 40 potential YSOs are identified with a MIPS and 2MASS color-color diagram and by their spectral indices, including two previously unknown sources with 24 micron excesses. Our new SIMBA millimeter map of Cha II shows that only a small fraction of the gas is in compact structures with high column densities. The extended emission seen by MIPS is compared with previous CO observations. Some selected interesting sources, including two detected at 1 mm, associated with Cha II are discussed in detail and their SEDs presented. The classification of these sources using MIPS data is found to be consistent with previous studies.

Accepted by Astrophysical Journal

<http://xxx.lanl.gov/abs/astro-ph/0503670>

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

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

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

Dissertation Abstracts

Magnetospheric Accretion in Substellar Objects

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Ph.D dissertation directed by: Dr. Kurt S. J. Anderson

Ph.D degree awarded: May 2005

The shock resulting from magnetospheric accretion in low mass T Tauri stars produces a characteristic veiling continuum in the ultraviolet and blue spectral regions. Variability across the optical bands is expected due to rotational modulation of the hot spots formed at the base of the accretion column and from the non-periodic variability due to the inherently non-equilibrium nature of the accretion process. In addition, characteristic spectral features including signs of low surface gravity and strong permitted emission lines that form in the ballistic gas flows are key identifiers of accreting Classical T Tauris. Finally, a contribution to the near-IR flux is seen from thermal emission arising from the inner regions of the dusty circumstellar disk.

We use these observational signatures obtained from multi-epoch imaging of the Orion and South Taurus equatorial regions by the Sloan Digital Sky Survey to study the variation of these accretion signatures across the substellar boundary. We find that, with the exception of the near-IR excess, these signatures are present in both low mass stars and young brown dwarfs. The absence of detectable circumstellar disk emission at the lowest masses is attributed to a decrease in the contrast between the disk and the stellar photosphere. The persistence of these signatures across a range of inferred masses suggests a common underlying physics in the magnetospheric accretion process, and thus a common formation mechanism and environment.

We find that the variability as measured by the rms variation in magnitudes decreases for lower mass objects. Examination of the variability across the optical spectrum finds trends that are consistent with earlier studies of low mass T Tauris but indicates that other factors besides changes in the veiling continuum may contribute to the brightness fluctuations. A proposed candidate is the deuterium-burning pulsational instability that may occur in very low mass stars and brown dwarfs at very young ages.

<http://astro.nmsu.edu/~peregrin/accretion.pdf>

New Jobs

Early Stage Researcher Position at Meudon / Orsay (France) within the european FP6 network "The Molecular Universe" on the subject "Gas phase and icy H₂O in photon-dominated regions"

Submitted by: Evelyne Roueff

Electronic mail: evelyne.roueff@obspm.fr

An opportunity exists to study for a Ph.D. degree at the Observatory of Paris (under the direction of Prof. J. Le Bourlot, , LUTH and UMR 8102 du CNRS, Observatoire de PARIS, Section de Meudon, Place J. Janssen, F-92190 MEUDON, France (e-mail: jacques.lebourlot@obspm.fr)), with secondment at the Institut d'Astrophysique Spatiale, Orsay, France (in the team of Prof. F. Boulanger, Institut d'Astrophysique Spatiale, Bat. 121, Universite Paris 11, 91405 Orsay cedex (e-mail: francois.boulanger@ias.fr)).

General introduction

Molecular water is ubiquitous in the universe and is present both in the gas phase and on dust grains as the main constituent of molecular ices. The HIFI instrument on board of the Herschel satellite will provide the first extensive opportunity to study this basic molecule in the gas phase whereas ISO, followed by SPITZER, bring information on the infra red features resulting from ices. On the molecular physics side, spectroscopic and dynamical studies of water is an active field of research and a central topic of the FP6 "Molecular Universe" program. The present proposition aims to gather the various knowledge obtained on this molecule and include them as accurately as possible in chemical interstellar models. Comparison with forthcoming observations is expected.

Methods

This graduate project will combine a physical model of a PDR region with a chemical kinetic model of water formation and destruction. As well as investigating the gas-phase formation of water and its contribution to the cooling, the project will also include the role of grains. Ice chemistry and desorption processes will be included in the gas phase model built in the Meudon team (cf. <http://aristote.obspm.fr/MIS/>) which will be modified to include advection of matter from the shielded interior of molecular clouds to their warmer surfaces penetrated by UV photons. These modifications will enable us to investigate the impact of ice desorption on gas chemistry, in particular water abundance and oxygen containing species. The evolution of the grains themselves will be considered. Some contribution to the FP6 Paris Observatory Data base project is expected.

Application

The position is available from September 15th 2005. Letters of application for this position should be sent by June 15, 2005 to the address above. The application should include a curriculum vitae together with a detailed list of university courses taken and their grades, as well as a brief statement of research experience. The applicant should arrange for two letters of recommendation by persons familiar with his/her undergraduate studies and/or research to be sent to the same address by the deadline. Qualified women candidates are specifically encouraged to apply.

Information on the PDR code of the Observatoire de Paris-Meudon team can be found at <http://aristote.obspm.fr/MIS/>
All applicants should be aware of the nationality and age constraints associated with this position.

**Postdoctoral Positions and Visiting Fellowship Positions
in Star Formation**

**Theoretical Institute for Advanced Research in Astrophysics (TIARA), Academia
Sinica and National Tsing Hua University, Taiwan
(<http://www.tiara.sinica.edu.tw>)**

The newly established Theoretical Institute for Advanced Research in Astrophysics (TIARA) is seeking applications to fill several postdoctoral positions and visiting fellowship positions in theoretical and computational astrophysics in Star Formation, starting in Fall 2005 or earlier. Postdoctoral appointments are for an initial two year term and the visiting fellow appointments are for durations of two to twelve months.

TIARA is a joint collaboration between the National Tsing Hua University based in Hsinchu and Academia Sinica based in Taipei and has a mission to carry out research at the highest level and to establish a vigorous visitors program in theoretical astrophysics. Scientists connected with TIARA are Michael Cai, Hsiang-Kuang Chang, Dean-Yi Chou, Hsien Shang, Frank Shu, and Chi Yuan in Taiwan and Eugene Chiang, Dong Lai, Zhi-Yun Li, Doug Lin, B.C. Low, Chung-Pei Ma, Ue-Li Pen, and Ronald Taam in North America. More information about members and activities can be found on <http://www.tiara.sinica.edu.tw>.

Present research at TIARA include investigations in the areas of Cosmology and Large Scale Structure, Galactic Dynamics, Star and Planet Formation, Solar Physics, High Energy/Relativistic Astrophysics and Computational Fluid Dynamics and Magnetohydrodynamics. The successful candidates will also have the opportunity for collaborations with scientists in the ongoing observational programs (SMA, AMiBA, CFHT, and TAOS projects within the Academia Sinica Institute of Astronomy and Astrophysics; <http://www.asiaa.sinica.edu.tw>).

Strong candidates in all areas of star formation should submit a curriculum vita, a brief summary of research and future research plans, and arrange for three letters of recommendation to be sent to Ms. Rebecca Zheng, TIARA Star Formation Positions, Dept. of Physics, National Tsing Hua University, 101, Sec. 2, Kuang-Fu Rd., Hsin-Chu, Taiwan 300; E-mail submission: tiara-admin@tiara.sinica.edu.tw. Inquiries should be made to Dr. H. Shang (shang@tiara.sinica.edu.tw).

The closing date for applications is June 15, 2005.

**Post-doctoral position in star formation and its relationship with the ISM
(UCL, London)**

A PPARC-supported position for a postdoctoral research assistantship is available, to work on a programme of theoretical research relating to the inter-relationship between star-forming regions and the interstellar medium. It is expected that the PDRA will be involved in the development and application of chemical and radiative transfer models to study the chemical and physical conditions in star-forming regions. Although this is a primarily theoretical programme, an important aspect of the work will involve the analysis of observational data in the context of these models.

The PDRA will work with Drs. Jonathan Rawlings and Serena Viti at UCL. Resources favour an appointment at the lower end of the Research Staff Scale 1A, so that the position is particularly appropriate for a recent PhD graduate.

The appointment will initially be for one year, with renewal for a further two years subject to satisfactory performance. Candidates should have a background in computational modelling and/or molecular astrophysics, with a strong interest in star-formation studies.

Prospective applicants are encouraged to make informal contact with Dr. J. Rawlings (jcr@star.ucl.ac.uk; +44-(0)20-7679-3471), or Dr. Viti (sv@star.ucl.ac.uk; +44-(0)20-7679-3435). Applications should be in the form of a full curriculum vitae including the names and addresses of two referees and should be sent to Dr. J. Rawlings, Department of Physics and Astronomy, University College London, Gower Street, London WC1E 6BT.

The closing date for applications is 30th June 2005.

New Books

A Color Atlas of Meteorites in Thin Section

Dante S. Lauretta and Marvin Killgore

This book presents an atlas of high quality color photographs of almost all types of stony meteorites. Different sections of the book cover ordinary, enstatite, carbonaceous, K, and R chondrites, as well as primitive and evolved achondrites (the latter including samples of Lunar and Martian meteorites). Each of the sections are preceded by a discussion of the class. For each meteorite is given its name, discovery date and place, classification, and present location. Two full-page photos first show a thin section in plane-polarized and in cross-polarized light. This is followed by a smaller region seen as plane-polarized, cross-polarized, reflected-light, and back-scattered electron images. The atlas demonstrates the enormous diversity of meteorite classes and illustrates each petrologic type of stony meteorites. This book is valuable for meteoriticists as both a research tool and a teaching tool. But for those of us who do not work directly in the field of meteoritics, the book offers an easily accessible introduction to classification of stony meteorites, plus the aesthetic pleasure of viewing a magnificent collection of beautiful images.

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Atlas and Catalog of Dark Clouds

K. Dobashi, H. Uehara, R. Kandori, T. Sakurai, M. Kaiden, T. Umemoto, and F. Sato

This is a major and very useful study which has just appeared in a special issue of the Publication of the Astronomical Society of Japan. The authors have used specially developed software to analyze the "Digitized Sky Survey I" to produce a map of visual extinction A_V with angular resolutions of 6" and 18". Based on this, the authors have produced a quantitative atlas and new catalog of dark clouds all along the Galactic plane for Galactic latitudes $|b| < 40^\circ$. In total, 2448 dark clouds were identified, with 2841 clumps located inside them.

The study is divided into the following sections:

1. Introduction
2. Data and Methods
 - 2.1 The Digitized Sky Survey
 - 2.2 Detection of Stars
 - 2.3 Photometric Calibration
 - 2.4 Measurement of the Actual and the Background Stellar Densities
 - 2.5 Conversion to A_V Map
 - 2.6 Uncertainties of the A_V Map
3. Atlas and Catalog of Dark Clouds
 - 3.1 High-Resolution A_V Map
 - 3.2 Low-Resolution A_V Map
 - 3.3 Distribution of the Identified Dark Clouds
4. Comparison with a Map Derived from Far-Infrared Dust Emission
5. Summary

The extinction maps can be accessed as FITS files together with a list of clouds (ASCII) on the web site of the authors at

<http://astro.u-gakugei.ac.jp/~tenmon/Atlas/index.html>

It is possible to order individual copies of this special issue of PASJ by contacting the Maruzen company through the contact information listed below. The issue contains 386 pages, most of which are devoted to 9 tables and 38 figures. The price (which includes postage) is 3900 Yen (approximately US\$ 38).

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Star Formation at High Angular Resolution

Edited by Michael Burton, Ray Jayawardhana and Tyler Bourke

These are the proceedings of the 221th IAU Symposium, which was held in Sydney during the IAU General Assembly in July 2003. The use of new techniques to gain higher angular resolution have had a major impact on the study of star forming regions during recent years. The development and increasing use of adaptive optics in the optical and near-infrared, the construction of mm and sub-mm interferometers and further developments of cm-wavelength radio interferometers have all offered new insights into the formation of both low-mass and high-mass young stars.

The book is divided into the following sections:

- Part 1. Star Formation
- Part 2. From Molecular Clouds to Protostellar Cores
- Part 3. Extra-Galactic Star Formation
- Part 4. Massive Star Formation
- Part 5. Low Mass Star Formation
- Part 6. First Results from New Facilities
- Part 7. Jets and Outflows
- Part 8. Disks
- Part 9. The Influence of Planets During Star Formation
- Part 10. The Future of Star Formation at High Angular Resolution

ISBN 1-58381-161-3, hardbound, 513 pages,
US\$ 42.00 for IAU Members, otherwise US\$95.00

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Meetings

Origins of Solar Systems Gordon Research Conference

Submitted by: Joseph Nuth

Electronic mail: nuth@gsfc.nasa.gov

The 2005 Gordon Research Conference on Origins of Solar Systems will be held June 26 July 1, 2005 at Connecticut College in New London, Connecticut. The Conference Chair is Joseph Nuth of the NASA Goddard Space Flight Center. Here is a link to the program as it appears at the Gordon Research Conferences website:

<http://www.grc.org/programs/2005/origins.htm>

Preliminary Schedule

1. Spitzer Observations of Protoplanetary Disks

Dan Watson: Structure and composition of protoplanetary disks – *Paola D’Alessio:* Disk evolution

2. Disk Chemistry from Comets, Meteorites and Spitzer

Paola Caselli: Chemistry in PreStellar Cores – *Bruce Fegley:* Nebular Processes – *Anita Cochran:* Cometary Constraints on Nebular Processes

3. Genesis Mission: Initial Composition of the Solar System

Charles Hohenberg: Noble Gas Measurements – *Robert Pepin:* Nitrogen Measurements

4. Constraints on Nebular Processes from Presolar Grains

Scott Messenger: PreSolar Silicates – *Ann Nguyen:* In situ Observations of Interstellar Grains – *Gary Huss:* Constraints from Presolar Grains

5. Local Production of Short-Lived Radio Isotopes

Eric Feigelson: Chandra Observations of Energetic Events – *Kevin McKeegan:* Which isotopes can be made in the solar nebula?

6. Disk Dynamics: The Formation and Migration of Planets

Scott Kenyon: Formation of the Outer Planets – *Richard Nelson:* Planet Migration – *Uma Gorti:* Disk Dispersal

7. Presolar Production of Short-Lived Radio Isotopes

Roger Chevalier: Supernovae- Production & Delivery – *Al Cameron:* Short lived isotopes and Solar System Formation

8. Comparative Planetology: Is the Earth Unique?

Geoffrey Taylor: Formation of the Earth-Moon system – *Michael Drake:* Delivery of water and other stuff to the early Earth

9. What have we learned from Extrasolar Planetary Systems?

Artie Hatzes: Observations of other planetary systems – *Alan Boss:* Interpretation of the observations

Protostars and Planets V
Hilton Waikoloa, Hawaii
24 – 28 October 2005

Registration for the Protostars and Planets V conference is now open. All information, together with a list of oral presentations, is now available at the conference web site at

<http://www.lpi.usra.edu/meetings/ppv2005>

Participants are encouraged to register and make their travel arrangements early, in order to get the most convenient and best priced airline connections.

Summerschool on "Molecules in Regions of Star Formation"

The European Network "The Molecular Universe" organizes a summerschool on "Molecules in Regions of Star Formation" from September 26 through September 30, 2005 at Les Houches, France.

This summerschool aims at providing graduate students and young postdocs with a thorough background in the techniques of molecular astrophysics and apply these to molecules in regions of star formation.

Over the next five years, European ground-based and space-based missions will open up the universe to high spatial and spectral resolution studies at infrared and submillimeter wavelengths. This will allow us to study, in much greater detail, the composition and the origin and evolution of molecules in space. Moreover, molecular transitions in these spectral ranges provide a sensitive probe of the dynamics and the physical and chemical conditions in a wide range of objects at scales ranging from budding planetary systems to galactic and extragalactic sizes. Hence, these missions provide us with the tools to study key astrophysical and astrochemical processes involved in the formation and evolution of planets, stars, and galaxies.

Molecular astrophysics is a highly interdisciplinary field where physics, chemistry, and astronomy intersect. Interpreting and analyzing the multitude of astronomical data that will become available will require a sound understanding of the basics of spectroscopy, collisional excitation, radiative transfer, and chemical reactions, involving molecules of astrophysical interest.

Details on the summerschool, including registration, are accessible through the website of the network at

<http://molecular-universe.obspm.fr/>

Star Formation in the Era of Three Great Observatories

A workshop sponsored by
the Chandra X-ray Center
Co-Sponsored by The Spitzer Science Center
hosted in Cambridge, MA
July 13-15, 2005
<http://cxc.harvard.edu/stars05/>

The goal of the workshop is to review topics in star-formation which are inherently multiwavelength, and to both define the current state of knowledge and the points of current controversy where new observations are most needed. We plan to focus on topics for which the Great Observatories have the most to contribute during this unique period of simultaneous operation. We will also consider observations from other facilities as well as theoretical work. We anticipate coverage of galactic and local-group star forming regions and potentially galaxies of the local group. We hope to come away with a list of future strategies and goals to be presented to NASA and the project leaders of each of the three telescopes.

- Early registration has passed, but a few slots are still available.
- DEADLINE: Late Abstract Submission deadline is June 3 or when all remaining slots are full.
- Registration fee: There is no registration fee You may submit abstracts and register at:
<http://cxc.harvard.edu/stars05/registration/registration.html>
- Book your hotel room: conference rates are available through June 12
<http://cxc.harvard.edu/stars05/registration/accommodations.html>

E-mail contact: stars05@cfa.harvard.edu

Moving ... ??

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