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Abstracts of recently accepted papers

The brown dwarf desert as a consequence of orbital migration

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We show that the dearth of brown dwarfs in short-period orbits around Solar-mass stars – the brown dwarf desert – can be understood as a consequence of inward migration within an evolving protoplanetary disc. Brown dwarf secondaries forming at the same time as the primary star have masses which are comparable to the initial mass of the protoplanetary disc. Subsequent disc evolution leads to inward migration, and destruction of the brown dwarf, via merger with the star. This is in contrast with massive planets, which avoid this fate by forming at a later epoch when the disc is close to being dispersed. Within this model, a brown dwarf desert arises because the mass at the hydrogen burning limit is coincidentally comparable to the initial disc mass for a Solar mass star. Brown dwarfs should be found in close binaries around very low mass stars, around other brown dwarfs, and around Solar-type stars during the earliest phases of star formation.

Accepted by MNRAS

Preprints are available at: http://arXiv.org/abs/astro-ph/0112001

High Resolution 4.7 μm Keck/NIRSPEC Spectra of Protostars. I: Ices and Infalling Gas in the Disk of L1489 IRS

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We explore the infrared M band (4.7 μm) spectrum of the class I protostar L1489 IRS in the Taurus Molecular Cloud. This is the highest resolution wide coverage spectrum at this wavelength of a low mass protostar observed to date (R =25,000; Δv =12 km s^{-1}). A large number of narrow absorption lines of gas phase ^{12}CO, ^{13}CO, and C^{18}O are detected, as well as a prominent band of solid ^{12}CO. The gas phase ^{12}CO lines have red shifted absorption wings (up to 100 km s^{-1}), which likely originate from warm disk material falling toward the central object. Both the isotopes and the extent of the ^{12}CO line wings are successfully fitted with a contracting disk model of this evolutionary transitional object (Hogerheijde 2001). This shows that the inward motions seen in millimeter wave emission lines continue to within $\sim$0.1 AU from the star. The amount of high velocity infalling gas is however overestimated by this model, suggesting that only part of the disk is infalling, e.g. a hot surface layer or hot gas in the magnetic field tubes. The colder parts of the disk are traced by the prominent CO ice band. The band profile results from CO in 'polar' ices (CO mixed with H_2O), and CO in 'apolar' ices. At the high spectral resolution, the 'apolar' component is, for the first time, resolved into two distinct components, likely due to pure CO and CO mixed with CO_2, O_2 and/or N_2. The ices have probably experienced thermal processing in the upper disk layer traced by our pencil absorption beam: much

of the volatile 'apolar' ices has evaporated, the depletion factor of CO onto grains is remarkably low (∼7%), and the CO_2 traced in the CO band profile was possibly formed energetically. This study shows that high spectral resolution 4.7 μm observations provide important and unique information on the dynamics and structure of protostellar disks and the origin and evolution of ices in these disks.

Accepted for publication in ApJ

Preprints soon available at www.submm.caltech.edu/∼boogert/publ.html

Rapid Formation of Ice Giant Planets

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The existence of Uranus and Neptune presents severe difficulties for the core accretion model for the formation of ice giant planets. We suggest an alternative mechanism, namely disk instability leading to the formation of gas giant protoplanets, coagulation and settling of dust grains to form ice/rock cores at their centers, and photoevaporation of their gaseous envelopes by a nearby OB star, as a possible means of forming ice giant planets.

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Preprint available at http://www.ciw.edu/boss/ftp/planets/icaice.ps

Mid-Infrared Detection of a Hot Molecular Core in G29.96-0.02

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We present high angular resolution (∼0.5″) 10 and 18 μm images of the region around G29.96-0.02 taken from the Gemini North 8-m telescope using the mid-infrared imager and spectrometer OSCIR. These observations were centered on the location of a group of water masers, which delineate the site of a hot molecular core believed to contain an extremely young, massive star. We report here the direct detection of a hot molecular core at mid-infrared wavelengths at this location. The size and extent of the core at 18 μm appears to be very similar to the morphology as seen in integrated NH_3 maps. However, our observations indicate that the mid-infrared emission may not be exactly coincident with the NH_3 emission.

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http://www.ctio.noao.edu/ debuizer

Gravitational Instabilities in the Disks of Massive Protostars as an Explanation for Linear Distributions of Methanol Maser

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Evidence suggests that some masers associated with massive protostars may originate in the outer regions of large disks, at radii of 100's to 1000's of AU from the central mass. This is particularly true for methanol (CH_3OH), where linear distributions of masers are found with disk-like kinematics. In 3D hydrodynamics simulations we have made to

study the effects of gravitational instabilities in the outer parts of disks around young low-mass stars, the nonlinear development of the instabilities leads to a complex of intersecting spiral shocks, clumps, and arclets within the disk and to significant time-dependent, nonaxisymmetric distortions of the disk surface. A rescaling of our disk simulations to the case of a massive protostar shows that conditions in the disturbed outer disk seem conducive to the appearance of masers if it is viewed edge-on.

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The Parker Instability in 3-D: Corrugations and Superclouds Along the Carina-Sagittarius Arm

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Here we present three-dimensional MHD models for the Parker instability in a thick magnetized disk, including the presence of a spiral arm. The B-field is assumed parallel to the arm, and the model results are applied to the optical segment of the Carina-Sagittarius arm. The characteristic features of the undular and interchange modes are clearly apparent in the simulations. The interchange mode appears first and generates small interstellar structures in the inter-arm regions, but its development inside the arm is hampered by the acceleration of the spiral wave. In contrast, the undular mode follows its normal evolution inside the spiral wave, creating large gas concentrations distributed along the arm. This results in a clear arm/inter-arm difference: the instability triggers the formation of large interstellar clouds (with masses in the range of 10^6 to 10^7 $M_\odot$) inside the arms, but generates only small structures with slight density enhancements in the inter-arm regions. The resulting clouds are distributed in an antisymmetric way with respect to the midplane, and their masses are similar to those inferred for HI superclouds in our Galaxy. Such a cloud distribution results in an azimuthal corrugation along the arm and, for conditions similar tothose of the optical segment of the Carina-Sagittarius arm, it has a wavelength of about 2.4 kpc. This structuring, then, can explain the origin of both HI superclouds and the azimuthal corrugations in spiral arms. In particular, the wavelength of the fastest growing undular mode matches the corrugation length derived with the young stellar groups located in the optical segment of the Carina-Sagittarius arm.

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The paper is posted in astro-ph/0111406

Methanol and silicon monoxide observations toward bipolar outflows associated with Class 0 objects

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We report SEST observations of seven bipolar outflows thought to be associated with Class 0 objects in the $v = 0$ $J = 3 \rightarrow 2$ and $J = 2 \rightarrow 1$ transitions o f SiO and $J_k = 3_k \rightarrow 2_k$ and $J_k = 2_k \rightarrow 1_k$ transitions of CH_3OH. Methanol and silicon monoxide emission from outflowing gas were detected toward the lobes of four objects (NGC 2264G, IRAS 16293-2422, Serpens S68N, and Serpens SMM4). The SiO line profiles are characteristics of C-type bow shocks, showing a peak at a radial velocity close to, but displaced from, the ambient cloud velocity, and a gradual decrease in intensity from the peak toward higher flow velocities. There is a significant correlation between the column density of SiO and the terminal SiO flow velocity, which suggests a velocity selective enhancement in the production of SiO molecules. We find that the SiO abundance in the lobes is enhanced with respect to that of the ambient cloud by a factor of at least 330 in IRAS 16293-2422 and SMM4, 170 in NGC 2264G, and 80 in S68N. The CH_3OH abundance

is enhanced by a factor of 500 in IRAS 16293-2422, 330 in SMM4, 80 in S68N, and 23 in NGC 2264G. In addition we find that the dependence of the SiO/CO and CH_3OH/CO abundance ratios with radial flow velocity shows a steep increas e in the range from ~ 0 to $\sim 4-5$ km s^{-1} and a gradual decline toward higher flow velocities. In the remaining three sources (CG 30, IRAS 13036-7644, and VLA 1623-243) emission in methanol was detected from a narrow line at the velocity of the ambient cloud, and no emission was detected in silicon monoxide. Weak methanol emission from a low-velocity outflow component was detected toward CG 30.

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Possible evidence for shocks in hot cores

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The NS/CS ratio can be used to test if shocks or thermal evaporation remove grain ices during massive star formation. The two scenarios lead to differences in the subsequent chemistry: in particular, timescales are shorter if shocks are present. We have measured NS/CS ratios in six hot core sources through observation of high excitation NS, $N^{34}S$, $C^{34}S$ and $C^{33}S$ with the JCMT. The NS/CS ratios we find are low, 0.02–0.05, and surprisingly consistent between sources. Comparing with the models of Viti et al. (2001), these values rule out the standard assumption of instantaneous thermal evaporation, and favour a scenario in which hot cores are shocked at an early stage with all grain mantles evaporating instantaneously.

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preprints at: http://www.mpifr-bonn.mpg.de/staff/mhatchell/

Planet Formation in the Outer Solar System

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This paper reviews coagulation models for planet formation in the Kuiper Belt, emphasizing links to recent observations of our and other solar systems. At heliocentric distances of 35–50 AU, single annulus and multiannulus planetesimal accretion calculations produce several 1000 km or larger planets and many 50–500 km objects on timescales of 10–30 Myr in a Minimum Mass Solar Nebula. Planets form more rapidly in more massive nebulae. All models yield two power law cumulative size distributions, $N_C \propto r^{-q}$ with $q = 3.0$–3.5 for radii $r \geq 10$ km and $N_C \propto r^{-2.5}$ for radii $r \leq 1$ km. These size distributions are consistent with observations of Kuiper Belt objects acquired during the past decade. Once large objects form at 35–50 AU, gravitational stirring leads to a collisional cascade where 0.1–10 km objects are ground to dust. The collisional cascade removes 80% to 90% of the initial mass in the nebula in ~ 1 Gyr. This dust production rate is comparable to rates inferred for α Lyr, β Pic, and other extrasolar debris disk systems.

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preprints: http://xxx.lanl.gov/abs/astro-ph/0112120

Collisional Cascades in Planetesimal Disks I. Stellar Flybys

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We use a new multiannulus planetesimal accretion code to investigate the evolution of a planetesimal disk following a moderately close encounter with a passing star. The calculations include fragmentation, gas and Poynting-Robertson drag, and velocity evolution from dynamical friction and viscous stirring. We assume that the stellar encounter

increases planetesimal velocities to the shattering velocity, initiating a collisional cascade in the disk. During the early stages of our calculations, erosive collisions damp particle velocities and produce substantial amounts of dust. For a wide range of initial conditions and input parameters, the time evolution of the dust luminosity follows a simple relation, $L_d/L_\star = L_0/[\alpha + (t/t_d)^\beta]$. The maximum dust luminosity L_0 and the damping time t_d depend on the disk mass, with $L_0 \propto M_d$ and $t_d \propto M_d^{-1}$. For disks with dust masses of 1% to 100% of the 'minimum mass solar nebula' (1–100 $M_\oplus$ at 30–150 AU), our calculations yield $t_d \sim$ 1–10 Myr, $\alpha \approx$ 1–2, $\beta = 1$, and dust luminosities similar to the range observed in known 'debris disk' systems, $L_0 \sim 10^{-3}$ to 10^{-5}. Less massive disks produce smaller dust luminosities and damp on longer timescales. Because encounters with field stars are rare, these results imply that moderately close stellar flybys cannot explain collisional cascades in debris disk systems with stellar ages of $\sim$ 100 Myr or longer.

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preprints: http://xxx.lanl.gov/abs/astro-ph/0111384

animation: http://cfa-www.harvard.edu/ kenyon/pf/flyby/ani.html

Formation and Fragmentation of Gaseous Spurs in Spiral Galaxies

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Intermediate-scale spurs are common in spiral galaxies, but perhaps most distinctively evident in a recent image showing a quasi-regular series of dust lanes projecting from the arms of M51 (Scoville & Rector 2001). We investigate, using time-dependent numerical MHD simulations, how such spurs could form (and subsequently fragment) from the interaction of a gaseous interstellar medium with a stellar spiral arm. We model the gaseous medium as a self-gravitating, magnetized, differentially-rotating, razor-thin disk. The basic flow shocks and compresses as it passes through a local segment of a tightly-wound, trailing stellar spiral arm, modeled as a rigidly-rotating gravitational potential. We first construct one-dimensional profiles for flows with spiral shocks. When the post-shock Toomre parameter $Q_{\rm sp}$ is sufficiently small, self-gravity is too large for one-dimensional steady solutions to exist. The critical values of $Q_{\rm sp}$ are $\sim$0.8, 0.5, and 0.4 for our models with zero, sub-equipartition, and equipartition magnetic fields, respectively. We then study the growth of self-gravitating perturbations in fully two-dimensional flows, and find that spur-like structures rapidly emerge in our magnetized models. We associate this gravitational instability with the magneto-Jeans mechanism, in which magnetic tension forces oppose the Coriolis forces that would otherwise prevent the coalescence of matter along spiral arms.The shearing and expanding velocity field shapes the condensed material into spurs as it flows downstream from the arms. Although we find swing amplification can help form spurs when the arm-interarm contrast is moderate, unmagnetized systems that are quasi-axisymmetrically stable are generally also stable to nonaxisymmetric perturbations, suggesting that magnetic effects are essential. In nonlinear stages of evolution, the spurs in our models undergo fragmentation to form $\sim 4\times10^6$ $M_\odot$ clumps, which we suggest could evolve into bright arm and interarm H II regions as seen in spiral galaxies.

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Preprints available at `http://www.arXiv.org/abs/astro-ph/0111398`
Associated movies in Animated GIF or mpeg format available at `http://www.astro.umd.edu/~kimwt/MOVIES/`
Scoville & Rector 2001, HST press release at `http://oposite.stsci.edu/pubinfo/PR/2001/10/index.html`

On the Role of Massive Stars in the Support and Destruction of Giant Molecular Clouds

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We argue that massive stars are the dominant sources of energy for the turbulent motions within giant molecular clouds, and that the primary agent of feedback is the expansion of H II regions within the cloud volume. This conclusion is suggested by the low efficiency of star formation and corroborated by dynamical models of H II regions.

We evaluate the turbulent energy input rate in clouds more massive than a third of a million solar masses, for which gravity does not significantly affect the expansion of H II regions. Such clouds achieve a balance between the decay of turbulent energy and its regeneration in H II regions; summed over clouds, the implied ionizing luminosity and star formation rate are roughly consistent with the Galactic total. H II regions also photoevaporate their clouds: we derive cloud destruction times somewhat shorter than those estimated by Williams and McKee. The upper mass limit for molecular clouds in the Milky Way may derive from the fact that larger clouds would destroy themselves in less than one crossing time. The conditions within starburst galaxies do not permit giant molecular clouds to be supported or destroyed by H II regions, and this may explain some aspects of the starburst phenomenon.

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Gas and dust emission in the Lupus globular filaments GF 17 and GF 20

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We present large-scale millimeter molecular line observations as well as IRAS co-added images of the globular filaments GF 17 and GF 20 in the southern con stellation of Lupus. A comparison is made of the extended far-infrared emission detected by IRAS at 60 and 100 μm and the CO $(1-0)$, ^{13}CO $(1-0)$, and C^{18}O $(1-0)$ emission in GF 17 and GF 20. Based on the far-infrared emission estimates of the dust temperature, optical depth, and visual extinction are derived. We find a correlation between the measured dispersion in our extinction determinations and the extinction toward the clouds, which is very similar to that found for other clouds, and interpret this as evidence that the cloud edges are characterized by a smooth density gradient. We find a remarkably good agreement between our 100 μm optical depth images and the ^{13} CO integrated emission maps. The dust 100 μm optical depth is well correlated with the gas column density suggesting that the far-infrared emission must originate from a substantial depth in the clouds. The dust temperature is found to be anticorrelated with the gas column density indicating that these clouds are heated externally. Our calculated far-infrared luminosities of GF 17 and GF 20 imply that the dominant source of dust heating is the ISRF due to the nearby Sco OB2 association. Analysis of the gas velocity structure within GF 17 and GF 20 reveals evidence for smooth large-scale streaming motions along the filamentary structures with magnitude ~ 0.5 km s^{-1} pc^{-1}. Our results indicate that the velocity gradients are likely due to the interaction of GF 17 and GF 20 with the Upper-Scorpius and Upper- Centaurus-Lupus HI expanding shells, via propagating shock fronts.

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Structure and Instabilities of an Irradiated Viscous Protoplanetary Disk

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We investigate the structure and the stabilities of a protoplanetary disk, which is heated by viscous process in itself and by its central star. The disk is set to rotate with the Keplerian velocity and has the surface density distribution of the minimum mass solar nebula. We assume the vertical hydrostatic equilibrium and the radiative equilibrium at each point, and solve the two-dimensional radiative transfer equation by means of the Short Characteristic method in the spherical coordinate in order to determine the disk structure. Our calculation shows that at the outer region of the disk with a distance from the central star of $x > 1$AU the radiative heating from the inner disk dominates the viscous heating even near the midplane. It is because of the high temperature distribution in the optically thin surface layer and the relatively high disk height ($z_\infty \sim 0.7x$ at $x \sim 1$AU) as a consequence of the irradiation from the inner hot region of the disk. In addition, we examine the convective and the magnetorotational instabilities of the disk. As a result, the whole disk is convectively stable since the dusty region is not heated by the viscous dissipation from the midplane but by the radial radiative heating. On the other hand, almost all the disk is magnetorotationally

unstable except for the region near the equatorial plane of $2\mathrm{AU} < x < 10\mathrm{AU}$. Finally we discuss the growth and the size distribution of dust particles in the disk, which suggests that there exist cm-sized particles in the surface layer, namely, in the exposed region of the disk.

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Infrared observations of NGC 3603 I. New constraints on cluster radius and K_s-band luminosity function

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We have performed deep K_s-band observations of the starburst region NGC 3603 with the infrared camera ISAAC mounted on the VLT Antu. The total area covered by our data stretches from the NGC 3603 starburst cluster towards the south up to a maximal distance of about $370''$ (~ 12 pc). This enables us to reconsider and redetermine the radial extent of the cluster which is found to be about $150'' \pm 15''$ (~ 5 pc), exceeding previous estimates by a factor of 2.5. King model fits are used to disentangle the count statistics of cluster stars from those of field stars. With knowledge of the cluster radius we then construct and analyze the K_s-band luminosity function (KLF) of the NGC 3603 starburst cluster. The KLF for cluster radii $> 30''$ is rising down to the completeness limit of our study at $K_s \sim 17^{\mathrm{m}}$–$17\overset{\mathrm{m}}{.}5$, corresponding to 1 Myr old cluster members of $\mathcal{M} \sim 0.5\,\mathcal{M}_\odot$. For the range of intermediate luminosity stars we obtain a KLF slope of $\alpha = 0.35 \pm 0.02$ which is consistent with a Miller-Scalo type initial mass function (IMF) of a $\sim$1 Myr old stellar cluster if one assumes a power-law index of $\beta \sim 2$ for the mass-luminosity relation of both intermediate mass main sequence stars and low mass pre-main sequence stars. At the high luminosity end the observed KLF likely flattens ($\alpha \sim 0.2$), being consistent with a Salpeter type IMF for NGC 3603's massive main sequence stars.

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Widespread atomic gas emission reveals the rotation of the β Pictoris disk

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We present high resolution Na I D spectroscopy of the β Pic disk, and the resonantly scattered sodium emission can be traced from less than 30 AU to at least 140 AU from the central star. This atomic gas is co-existent with the dust particles, suggestive of a common origin or source. The disk rotates towards us in the south-west and away from us in the north-east. The velocity pattern of the gas finally provides direct evidence that the faint linear feature seen in images of the star is a circumstellar disk in Keplerian rotation. From modelling the spatial distribution of the Na I line profiles we determine the effective dynamical mass to be $(1.40 \pm 0.05)\,\mathrm{M}_\odot$, which is smaller than the stellar mass, $1.75\,\mathrm{M}_\odot$. We ascribe this difference to the gravity opposing radiation pressure in the Na I lines. We argue that this is consistent with the fact that Na is nearly completely ionised throughout the disk ($\mathrm{Na\,I/Na} < 10^{-4}$). The total column density of sodium gas is $N(\mathrm{Na}) = 10^{15}\,\mathrm{cm}^{-2}$.

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http://www.arxiv.org/abs/astro-ph/0111206

ISO-LWS two colour diagram of young stellar objects

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We present a [60–100] vs. [100–170] μm two colour diagram for a sample of 61 young stellar objects (YSOs) observed with the Long Wavelength Spectrometer (LWS) on-board the Infrared Space Observatory (ISO). The sample consists of 17 Class 0 sources, 15 Class I, 9 Bright Class I ($L_{\rm bol} > 10^4\,L_{\odot}$), 20 Class II (14 Herbig Ae/Be stars and 6 T Tauri stars). We find that each class occupies a well defined region in our diagram with colour temperatures increasing from Class 0 to Class II. Therefore the [60–100] vs. [100–170] two colour diagram is a powerful and simple tool to derive from future (e.g. with the Herschel Space Observatory) photometric surveys the evolutionary status of YSOs. The advantage over other tools already developed is that photometry at other wavelengths is not required: three flux measurements are enough to derive the evolutionary status of a source. As an example we use the colours of the YSO IRAS 18148−0440 to classify it as Class I. The main limitation of this work is the low spatial resolution of the LWS which, for some objects, causes a high uncertainty in the measured fluxes due to the background emission or to the source confusion inside the LWS beam.

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X-ray properties of the young stellar and substellar objects in the IC 348 cluster – the *Chandra* View

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We explore the X-ray properties of the young stellar and substellar objects in the open cluster IC 348 as seen in our deep *Chandra X-Ray Observatory* ACIS image. First, we give identifications of all X-ray sources and determine upper limits for the X-ray luminosities of the undetected cluster members. Then, we analyse the X-ray spectra of the young stellar objects, deriving plasma temperatures between ~ 0.7 keV and ~ 3 keV for the T Tauri stars in IC 348, and higher temperatures between ~ 3 keV and ~ 7 keV for flaring sources and two embedded young stellar objects. We find several large X-ray flares, in some of which a clear hardening of the X-ray spectra during the flare peak is seen.

Next, we use the exceptional optical, infrared, and X-ray data setof this cluster to study various correlations and their implications, and to discuss new answers to some long-standing questions related to X-ray emission from young (sub-) stellar objects. The X-ray luminosities of the young low-mass stars are strongly correlated to the stellar bolometric luminosities ($L_{\rm X} \sim 10^{-4} \times L_{\rm bol}$). Also, a good correlation between X-ray luminosity and stellar mass is found ($L_{\rm X} \propto M^2$). For the weak line T Tauri stars, we find a tight correlation between X-ray activity and chromospheric activity ($L_{\rm X} \propto L_{\rm H\alpha}^{0.8}$), supporting the hypothesis that the chromosphere is heated by X-rays from the overlying corona.

The observed X-ray properties of the brown dwarfs (and brown dwarf candidates) are very similar to those of late-type stars; we explain this behaviour as the consequence of the fact that very young substellar objects are still warm enough to maintain partially ionized atmospheres which are capable of sustaining electrical currents, while in the cooler neutral atmospheres of L and T dwarfs such currents are shut off (hence no X-ray emission).

Finally, we explore the difference between the X-ray luminosity functions of classical and weak-line T Tauri stars. We find that the classical T Tauri stars in IC 348 seem to be *on average* less X-ray luminous than the weak-line T Tauri stars. However, we suggest that this apparent difference is caused by a selection effect: there is a strong detection bias against those weak-line T Tauri stars which are optically faint and hence X-ray faint; the population of classical T Tauri stars, on the other hand, is essentially completely known due to its very prominent Hα emission. This conclusion is corroborated by another new result: When using a photometrically selected, magnitude limited, complete sample of T Tauri stars and taking the $K-L$ infrared excess as a tracer of circumstellar material, we find no evidence in IC 348 for a difference in X-ray properties of young stars with and without circumstellar matter; i.e. classical and "naked" T Tauri stars.

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Kinematics of the HH 111 jet from STIS spectra

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We present a long-slit spectrum of the Herbig-Haro object HH 111, obtained with STIS on the Hubble Space Telescope. This spectrum has a spectral resolution of ≈ 50 km s^{-1}, so that it gives a good picture of the kinematical properties of the observed object at very high angular resolution. We find that some of the knots along the jet are associated with sudden drops in the radial velocity (modulus), confirming that the emission from the knots is formed in shocks. We interpret the observed position-velocity diagrams in terms of a model of a jet from a variable source, and we attempt to carry out a reconstruction of the ejection velocity variability necessary for reproducing the observed kinematical structure.

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Photodissociation regions and star formation in the Carina Nebula

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We have obtained wide-field thermal infrared (IR) images of the Carina Nebula, using the SPIREX/Abu telescope at the South Pole. Emission from poly-cyclic aromatic hydrocarbons (PAHs) at 3.29μm, a tracer of photodissociation regions (PDRs), reveals many interesting well defined clumps and diffuse regions throughout the complex. Near-IR images (1–2μm), along with images from the Midcourse Space Experiment (*MSX*) satellite (8–21μm) were incorporated to study the interactions between the young stars and the surrounding molecular cloud in more detail. Two new PAH emission clumps have been identified in the Keyhole Nebula and were mapped in ^{12}CO(2–1) and (1–0) using the SEST. Analysis of their physical properties reveals they are dense molecular clumps, externally heated with PDRs on their surfaces and supported by external pressure in a similar manner to the other clumps in the region. A previously identified externally heated globule containing IRAS 10430-5931 in the southern molecular cloud, shows strong 3.29-, 8-, and 21-μm emission, the spectral energy distribution (SED) revealing the location of an ultra-compact (UC) H II region. The northern part of the nebula is complicated, with PAH emission inter-mixed with mid-IR dust continuum emission. Several point sources are located here and through a two-component black-body fit to their SEDs, we have identified 3 possible UC H II regions as well as a young star surrounded by a circumstellar disc. This implies that star formation in this region is on-going and not halted by the intense radiation from the surrounding young massive stars.

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Circumstellar Disk Candidates Identified in NGC 2264

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We present an optical and near-infrared study of a $45' \times 45'$ field in NGC 2264, which includes both S Mon and the Cone Nebula. We report photometry at optical ($UBVR_{\rm C}I_{\rm C}$) and near-infrared (JHK) wavelengths for ∼5600 stars, and spectroscopic classifications for ∼400 of these stars. We identify circumstellar disk candidates using three techniques: excess ultraviolet ($U-V$) emission, excess near-IR ($I-K$ and $H-K$) emission, and Hα emission line equivalent widths for those stars with spectra. We find generally good correlation between disk indicators thought to originate from different physical processes. We find little if any evolution of disk fraction with stellar age or mass. However, when we derive mass accretion rates ($\dot{M}$) from the excess emission at U, we find that $\dot{M}$ decreases with age over the age range spanned by our data, ∼0.1−5 Myr, and increases with mass over the range $\sim 0.25 - 1$ M$_\odot$. These findings are comparable to results found previously by us in the Orion Nebula Cluster Flanking Fields.

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Paper and data tables available online at `http://irastro.jpl.nasa.gov/~rebull/`

Radio Continuum and H92α Recombination Line Observations of G34.26+0.15 and G5.89-0.39

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We report VLA observations of 8.3 GHz continuum and H92α radio recombination line towards the star forming regions G34.26+0.15 and G5.89-0.39. Both regions show considerable mean optical depth in the continuum at 8.3 GHz, $\tau_C \simeq 2$, and the H92α line can be used to study opacity variations across the face of the nebula. We detected H92α emission in the ultracomponent component A of G34.26+0.15, but not in the ultracomponent component B. This result is puzzling since both ultracompact components are similar in continuum flux density and angular size. G5.89-0.39 shows strong velocity gradients in the H92α line, but these cannot be attributed only to rotation, as previously proposed.

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Accurate Stellar Population Studies from Multiband Photometric Observations

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We present a new technique based on multi-band near ultraviolet and optical photometry to measure both the stellar intrinsic properties, *i.e.* luminosity and effective temperature, and the interstellar dust extinction along the line of sight to hundreds of stars per square arcminute. The yield is twofold. On the one hand, the resulting reddening map has a very high spatial resolution, of the order of a few arcseconds, and can be quite effectively used in regions where the interstellar material is patchy, thus producing considerable differential extinction on small angular scales. On the other hand, combining the photometric information over a wide baseline in wavelength provides an accurate determination of temperature and luminosity for thousands of stars. As a test case, we present the results for the region around Supernova 1987A in the Large Magellanic Cloud imaged with the *WFPC2* on board the Hubble Space Telescope.

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http://www.eso.org/ mromanie/accurate.ps.gz

On Rossby waves and vortices with differential rotation

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We present a simplified model for linearized perturbations in a fluid with both differential rotation and differential vorticity. Without the latter the model reduces to the classical Shearing Sheet used in the description of spiral density waves in astrophysical disks. Without the former it reduces to the β-plane approximation, used in the description of Rossby waves in planetary atmospheres. Retaining both, our model allows one in general to discuss the coupling between density waves and Rossby waves, resulting in what is known as the "corotation resonance" for density waves. Here we will derive, as a first application of this model, the properties of Rossby waves in a differentially rotating disk. We find that their propagation is quenched by differential rotation: after a limited number of oscillations, a Rossby wave collapses to a singular vortex (a vorticity sheet), as fluid elements are sheared apart by differential rotation. In a keplerian disk, this number of oscillations is always lower than one. We also describe how, in a similar manner, a vortex is sheared in a very short time.

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Radio-millimetre investigation of galactic infrared dark clouds

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We present follow-up observations of the mid-Infrared dark clouds selected from the ISOGAL inner Galaxy sample. On-the-fly maps of ^{13}CO, C^{18}O and the 1.2 mm continuum emission were conducted at the IRAM 30-m telescope, showing spectacular correlation with the mid-IR absorption. The dark clouds are distributed as far as the prominent molecular ring at a distance of 3 to 7 kpc from the Sun. The clouds exhibit shapes ranging from globules to thin filaments down to ≤ 1 pc in size. The on-the-fly images obtained in ^{13}CO and C^{18}O confirmed that the cores are dense, compact molecular emitters, significantly more massive than local dark clouds (more than 1000 $M_\odot$) and lie within low activity Giant Molecular Clouds (GMC's). Ratios of the emission in the $J = (2-1)$ and $(1-0)$ transitions of ^{13}CO and C^{18}O show a remarkable uniformity within each cloud, with a significant portion of the sample represented well by a ratio of 0.67 ± 0.12. Preliminary analysis of temperature and density measurements reveals that most of the cores have densities above 10^5 cm^{-3} and temperatures between 8 and 25 K, these latter clouds being associated with young embedded stars. Despite the high extinction inferred from mid-IR ($A_v > 50$, Hennebelle et al. 2001), the molecular

lines are surprisingly weak, indicating likely depletion onto cold grains.

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Bispectrum speckle interferometry of the massive protostellar object S140 IRS 1: evidence for multiple outflows

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Bispectrum speckle interferometry is employed to explore the immediate environment of the deeply embedded young stellar object S140 IRS 1. A K'-band ($2.0 - 2.3\,\mu$m) diffraction-limited resolution of 76 mas ($\sim$ 70 AU) is achieved with the SAO 6 m telescope, as well as a dynamical range of more than 8 magnitudes and a field of view of $13'' \times 21''$. Our image exhibits many previously unseen complex structures. In addition to the bright, elongated, and very clumpy feature pointing from the central source to the south-east, which was already discussed in a previous paper (Schertl et al. 2000), we find several arc-like structures north-east of IRS 1, extended diffuse emission south of IRS 1, and four new point sources. The diffuse and fragmentary structures close to IRS 1 appear to trace circumstellar material swept up by energetic outflows. In combination with molecular line emission maps from the literature, our image provides direct confirmation that two distinct bipolar outflow systems continue to be driven from IRS 1 on scales between $3''$ and $100''$. A system of three arc-like structures to the north-east is consistent with cavities excavated by a precessing jet or wind-driven outflow. We discuss the implications for the nature of the central source.

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Gas flows around two young stellar clusters in NGC2264

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Observations of the dust and gas toward two young stellar clusters, IRS1 and IRS2, in the NGC2264 star forming region are presented. Continuum emission is used to locate the dusty envelopes around the clusters and individual protostars within and line emission from the $J = 3 - 2$ transitions of HCO^+ and $H^{13}CO^+$ is used to diagnose the gas flows around them. The molecular abundance, velocity centroid and dispersion are approximately constant across the IRS1 clump. With these constraints, the self-absorbed HCO^+ lines are modeled as a large scale collapse, with speed $v_{\rm in} = 0.3$ km s^{-1} and mass infall rate $\dot{M} = 4 \times 10^{-4}\ M_\odot$ yr^{-1}, falling onto an expanding central core. The signature of large scale collapse, with a similar speed and mass infall rate, is also found toward IRS2 but again appears disrupted at small scales. Individual protostars are resolved in this cluster and their size and velocity dispersion show that the stellar system is currently bound and no older than 5×10^5 yr, but is destined to become unbound and disperse as the surrounding cloud material is lost.

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Preprint available at: http://www.astro.ufl.edu/∼williams/biblio.html

Special NANTEN issue of PASJ

All of the following papers are based on observations with the NANTEN millimeter-wave telescope, and are accepted for publication in a special issue of Publ. Astron. Soc. Japan (Vol. 53, No. 6, 2001). Preprints can be found at http://www.a.phys.nagoya-u.ac.jp/NANTEN-PASJ2/

On the Mass Spectrum of Giant Molecular Clouds in the Large Magellanic Cloud

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Based on a new sensitive survey of the giant molecular clouds (GMCs) in the Large Magellanic Cloud, we derived the mass spectrum for them. In the mass range from $\sim 8 \times 10^4\,M_\odot$ to $3 \times 10^6\,M_\odot$, a power law with an index value of -1.9 ± 0.1 shows the best fit to the data. This is consistent with numerical simulations that explain both the H I and CO clumpy distributions by Wada et al. (2000; ApJ, 540, 797), but is significantly steeper than that of the GMCs in the Galaxy. This may be consistent with the drastic dissipation of the GMCs in the LMC due to higher UV radiation fields than in the Galaxy.

First Results of a CO Survey of the Small Magellanic Cloud with NANTEN

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We present the first results from a new ^{12}CO (J = 1–0) survey of the Small Magellanic Cloud (SMC) with the NANTEN millimeter-wave telescope. The survey covered the northeast and southwest regions of the main Bar, and the H II regions N 84, N 88 in the Wing at a linear resolution of $\sim$ 50 pc. Twenty-one giant molecular clouds (GMCs), whose masses are $\sim 10^4$–$10^6\ M_\odot$, were identified. Significant CO emission, $T_{\rm R}^* \sim 0.36$ K, was first detected toward the N 84 region in the Wing, which is comparable to those of the prominent CO clouds associated with infrared sources LIRS 36, LIRS 49 in the Bar. The GMCs exhibit a good spatial correlation with the H II regions and young clusters, indicating that cluster formation is on-going in these GMCs. On the other hand, they show little correlation with older clusters or with supernova remnants, suggesting rapid dissipation of CO.

Sensitive CO Observations of the LMC Supergiant Shells with NANTEN: Their Effects on the Formation of Molecular Clouds and Stellar Clusters

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A statistical study of the effects of supergiant shells (SGSs) on the formation of stars and molecular clouds was made based on sensitive CO(J =1–0) observations of the molecular clouds in the LMC with NANTEN. The sensitive observations have detected 168 CO clouds whose mass ranges from $\sim 4 \times 10^4 M_\odot$ to $3 \times 10^6 M_\odot$. Out of the 168 clouds, 63 are associated with the SGSs, accounting for $\gtrsim$ 35%. The surface number and mass densities of the CO clouds are higher by a factor of 1.5–2 at the edge of the SGSs than elsewhere. This suggests the formation of CO clouds under the dynamical effects of the SGSs, such as the accumulation of interstellar medium. Young stellar clusters are more actively formed on the side of the CO clouds facing to the center of the SGSs, particularly where the Hα filaments are adjacent to the CO clouds. The number of clusters is increased by a factor of 2 on the side facing to the center of the SGSs with respect to the CO peaks compared with on the side far from the center. These results strongly suggest that cluster formation is triggered by dynamical effects of the SGSs. We find that $\sim$ 60% of the young clusters are located within the boundary of the SGSs, and propose that a few 10% of the young clusters of $\tau < 10$ Myr have likely been formed due to dynamical effects of the SGSs.

A CO Survey of the LMC with NANTEN: II. Catalog of Molecular Clouds

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From a ^{12}CO (J = 1–0) survey with the NANTEN telescope, we present a complete catalog of giant molecular clouds (GMCs) in the Large Magellanic Cloud. In total, 107 CO clouds have been identified, 55 of which were detected at more than 3 observed positions. For the 55 clouds, the physical properties, such as size, line width, virial mass, and CO luminosity, are cataloged. ¿From a statistical analysis of these quantities, we show that GMCs in the LMC are close to gravitational equilibrium. A comparison with H I data indicates that most of the CO clouds are distributed in dense parts of H I gas, whose H I column density is greater than 10^{21}cm^{-2}. It is notable that the mass ratio of the molecular-to-atomic hydrogen of the lower radial velocity component of gas is ~ 0.2, which is a factor of 2 higher than that of the gaseous-disk component, ~ 0.1. Molecular clouds are apparently formed efficiently in the parent atomic clouds in the lower velocity component. The CO Arc, which is a few kpc scale ordered structure of CO clouds along the southern optical edge of the galaxy, corresponds well to the the lower velocity component of H I gas.

A CO Survey of the LMC with NANTEN: III.Formation of Stellar Clusters and Evolution of Molecular Clouds

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In order to elucidate star formation in the LMC, we made a complete study of CO clouds with NANTEN. In the present paper, we compare 55 giant molecular clouds (GMCs), whose physical quantities were well determined, with young objects, such as young stellar clusters and H II regions. We find that the GMCs are actively forming stars and clusters; 23 and 40 are found to be associated with the clusters and the H II regions, respectively. The clusters associated with the GMCs are significantly young; $\sim$ 85% of them are younger than $\sim$ 10 Myr. In addition, compact groups of the young clusters are often found at the peak position of the GMCs, e.g., N 159 and N 44, while much looser groups are away from the GMCs. This suggests that the clusters are formed in groups and disperse as they become old. The distributions of the CO, [C II], and UV indicate that the GMCs are likely to be rapidly dissipated within several Myr due to UV photons from the clusters. We also estimate the evolutionary time scale of the GMCs; they form stars in a few Myr after their birth, and form clusters during the next few Myr, and are dissipated in the subsequent few Myr.

Detection of Eight Molecular Supershells in the Southern Milky Way with NANTEN

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We carried out a new CO survey for molecular supershells in the southern Milky Way with NANTEN. We covered an area of $300^\circ < l < 350^\circ$ and $-9^\circ < b < 9^\circ$ at $4'$ or $8'$ grid spacings with a $2'.6$ beamsize. In addition to the disk component at $|b| < 2^\circ$, we found numerous filamentary or arc-like CO distributions by inspecting the velocity channel maps. As a result, we identified 8 supershell candidates, 3 of which are associated with CO holes in the galactic disk. Six of the supershells had not been identified by the previous studies, while 2 of them were known from H I and

low-resolution CO surveys. The size of the supershells ranges from 100 pc to 450 pc and the average is 230 pc; their age ranges from 2.2×10^6 yr to 1.1×10^7 yr. We note that two of the supershells are also associated with observable indications of supershells at other wavelengths, including H I, far-infrared, soft X-ray, and SNRs. The implications of these findings are discussed in terms of the impact of supershells on star formation in the Galaxy.

A Survey for High-Latitude Molecular Clouds toward Infrared-Excess Clouds with NANTEN

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A survey for high Galactic latitude molecular clouds was carried out toward the far-infrared-excess clouds of Reach et al. (1998, AAA 070.131.207) using the NANTEN telescope. All 68 infrared-excess clouds that are observable from NANTEN were mapped in the J=1–0 line of ^{12}CO. CO emission was detected from 32 infrared excess clouds, corresponding to a CO detection rate of 47%. Most of these CO clouds were identified and mapped as high-latitude clouds for the first time. The CO detection rate for the cold ($T_{\rm dust} < 17$ K) infrared excess clouds is 72%, which is more than a factor of two higher than that of warmer ones, 33%. This indicates that the cold clouds are well shielded from external UV radiation, resulting in a high CO abundance and a low temperature of the clouds. The infrared-excess clouds with no CO emission are most likely to be molecular hydrogen clouds because the temperature is similar to, or lower than, that of the surrounding H I gas. The molecular gas without CO emission seems to occupy more than 90% of the area of the infrared-excess clouds.

A ^{12}CO (J=1–0) Survey of Molecular Clouds toward the Vela Supernova Remnant with NANTEN

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The molecular distribution toward the whole extent of the Vela SNR has been obtained at a linear resolution of 0.15 pc in ^{12}CO (J=1–0) emission with the NANTEN telescope. The CO distribution is generally anti-correlated with the SNR. The X-ray distribution has a sharp boundary toward the CO clouds, especially in the east, suggesting an interaction between them. There is only weak CO emission in the west, and the X-ray emission extends smoothly toward this direction. This indicates that the absence of dense gas probably allowed hot gas to escape freely. The CO clouds are highly filamentary, exhibiting a spatial correlation with regions of optical shocked features on a large scale. In the north of the SNR, enhanced X-ray emission is found toward network-like optical filaments. We suggest that this enhancement is due to the evaporation of molecular gas by shock heating caused by the interaction between the blast wave and the molecular gas. Comparisons with a few simple theoretical models of SNR evolution and expansion indicate that the clouds are mostly pre-existent, are being accelerated, and are evaporating now.

The Most Massive C^{18}O Molecular Complex in Centaurus and Star Formation Therein

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New observations of the ^{12}CO, ^{13}CO, and C^{18}O (J = 1–0) emission lines have been extensively made toward the Centaurus tangential region ($308.^\circ5 \leq l \leq 310.^\circ5$ and $-1.^\circ0 \leq b \leq 1.^\circ0$) using the "NANTEN"telescope. These observations have revealed a massive molecular complex in C^{18}O of $\sim 1.8 \times 10^5$ $M_\odot$, the most massive one observed in C^{18}O to date in the Galaxy. This complex is highly elongated with a size of ~ 80 pc $\times \sim 25$ pc at $309^\circ \leq l \leq 309.^\circ5$

and $-0.^\circ9 \leq b \leq 0.^\circ4$, including 35 dense molecular clumps whose mass ranges from 4.7×10^2 $M_\odot$ to 3.4×10^4 $M_\odot$. Twenty-seven of the 35 clumps are associated with IRAS point sources whose luminosity ranges from 7.2×10^2 $L_\odot$ to 3.6×10^5 $L_\odot$. We find that the luminosity of the candidate protostellar IRAS sources is well correlated with the molecular line width, as fitted by a power law, $\log(L_{\rm IRAS}) = 1.1 + (9.2 \pm 0.6) \log(\Delta V)$. This suggests that the mass of the formed stars is determined by the internal velocity dispersion of the dense cores. A comparison with an H I distribution shows that the molecular gas forms a ring-like structure inside an H I hole of $\sim$ 55–70 pc radius. Since the H I gas surrounding the hole shows a signature of expansion at several km s^{-1}, we suggest that the H I hole exhibits a shell created by some explosive events, like supernovae, during the last $\sim$ (6–8) $\times 10^6$ yr. The ring-like structure of the CO distribution may be found due to the interaction between the expanding shell and the interstellar medium, leading to a trigger of massive star formation.

A Large-Scale Study of $H^{13}CO^+$ and $C^{18}O$ (J = 1–0) in Orion B

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We have made a new survey for dense cloud cores in the Orion B region using the NANTEN telescope. Two molecular transitions, the J = 1–0 line of $H^{13}CO^+$ and the J = 1–0 line of $C^{18}O$, were used to study the distribution of dense molecular gas with densities of 10^4–10^5 cm^{-3}. We detected 19 $C^{18}O$ clumps, and the mass and the size of the $C^{18}O$ clumps ranged from 13 $M_\odot$ to 990 $M_\odot$ and from 0.26 pc to 0.69 pc, respectively. Among the physical parameters of these $C^{18}O$ clumps, the molecular column density, $N(H_2)$, has been found to be the best indicator of star formation; the molecular column density averaged within a $C^{18}O$ clump shows a good correlation with the IRAS luminosity as $L_{\rm IRAS}$ ($L_\odot$) $\propto N(H_2)$ (cm^{-2}) $^{4.8\pm0.6}$ (C.C. = 0.96). We also detected 11 $H^{13}CO^+$ clumps, whose mass ranges from a few $M_\odot$ to 480 $M_\odot$. Five of the $H^{13}CO^+$ clumps are of smaller mass, and show no indication of massive star formation; they were newly found in this survey. Five of the eleven $H^{13}CO^+$ clumps are particularly massive with an average mass of $\sim$200 $M_\odot$. It is found that these massive $H^{13}CO^+$ clumps exhibit active formation of massive stars, as indicated by associated protostellar IRAS point sources, whose luminosities are 10^2–$10^4 L_\odot$.

Study of Molecular Clouds and Star Formation in the Region of IC 2118

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We carried out a ^{12}CO survey of molecular clouds in the region of the reflection nebula IC 2118. Our observations covered the whole area of IC 2118 ($\sim$ 6 deg^2) with a 2.′6 beam at a 4′ grid spacing. We identified six molecular clouds. Based on a literature search we found a distance value of 210 pc for the reflection nebula and its associated molecular clouds, indicating that the clouds are probably interacting with the Orion–Eridanus Bubble. Using this distance value, we determined the physical properties of the clouds. We also made an objective prism search for Hα emission stars in the region in order to find possible solar-type stars born in the clouds, and identified 46 candidate pre-main sequence stars. Their spectroscopic follow-up is in progress. Seven of them have so far been proven to be T Tauri stars.

A Large Scale ^{12}CO (J=1–0) Survey toward the Chamaeleon Region with NANTEN

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We carried out a large-scale survey for molecular clouds in ^{12}CO (J = 1–0) emission toward the Chamaeleon region with the NANTEN 4-meter radio telescope at Las Camapanas Observatory in Chile. The survey covered ∼491 deg^2 toward $284^\circ \lesssim l \lesssim 320^\circ$ and $-34^\circ \lesssim b \lesssim -6^\circ$ at an $8'$ grid spacing. The total molecular mass in the observed area is estimated to be $\sim 8300 M_\odot$. More than 60% of the total mass is concentrated in and around the previously known Cha I, II, and III dark clouds. Two cloud complexes having molecular hydrogen masses of $\sim 430 M_\odot$ and $\sim 1300 M_\odot$, respectively, have been found at ∼10° galactic-east of the Chamaeleon major clouds. We have identified a prominent filament extending from Cha I to the galactic-east direction, which is remarkably long, $\gtrsim$ 40 pc compared with filamentary features found in other dark-cloud complexes. A correlation study between the CO distribution and isolated X-ray emitting T Tauri stars (TTSs) indicates that $\gtrsim$ 65% of the TTSs are located within 1 pc of the ^{12}CO cloud boundaries. This suggests that low-density parental molecular gas still remains around the isolated TTSs, although the dense parts with density greater than 10^3 cm^{-3} have almost dissipated. This provides further support for the local formation of "isolated" T Tauri stars in small clouds.

Study of L 688/L 694/L 700: a Complex of Dark Clouds in Aquila

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We present the results of optical and radio molecular observations of the small dark clouds L 688, L 694, and L 700 (CB 200). Based on star counts, we found the distance of 230±30 pc for the clouds. We present extinction maps of the clouds on the basis of USNO Catalog data. Our objective prism search for candidate pre-main-sequence stars resulted in the detection of a Hα emission star in the cloud area. We observed the clouds in the ^{12}CO(1-0), ^{13}CO(1-0) and C^{18}O(1-0) lines. A ring-shaped cloud of $\sim 430 M_\odot$ was detected from the ^{12}CO observation. Five ^{13}CO cores were identified. Three C^{18}O cores with $N(H_2) \sim 5.3 - 7.6 \times 10^{21}$ cm^{-2} reside in two of the ^{13}CO cores in the northern part of the cloud. The density gradient seen in optical, infrared and radio, and also the positions of the star formation sites may suggest the possibility of shock compression due to some stars or SNRs near the galactic plane.

CO Column Density and Extinction in the Chamaeleon II–III Dark-Cloud Complex

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We carried out ^{13}CO(J = 1–0) and C^{18}O(J = 1–0) observations of the Chamaeleon II–III dark-cloud complex with the NANTEN radio telescope. The column densities of both molecular isotopes were derived assuming LTE. The A_V values were obtained by scaling the A_J values that were derived using an adaptive-grid star-count method applied to the DENIS J-band data. We established the A_V–CO isotope column-density relations in Cha II and III, and compared them with those in Cha I. The slopes of the A_V–^{13}CO relations for Cha II and III are steeper than that for Cha I. Those of the A_V–C^{18}O relations are similar among the three clouds. The total column density ratio, $N(^{13}\mathrm{CO})/N(\mathrm{C}^{18}\mathrm{O})$, in Cha I tends to be small compared with those in Cha II or Cha III; the ratios range from ∼ 5 to ∼ 25 at low extinction in Cha II and III, but at most ∼ 10 in Cha I. We suggest that the increase of $N(^{13}\mathrm{CO})$ due to the ^{13}CO formation process causes cloud-to-cloud variations in the A_V–$N(^{13}\mathrm{CO})$ correlation.

^{12}CO Molecular Cloud Survey and Global Star Formation in Lupus

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The Lupus star-forming region has been surveyed for molecular clouds in ^{12}CO with the NANTEN radio telescope, and a cloud mass of $1.7 \times 10^4 M_\odot$ has been revealed. We were able to detect 105 molecular clouds, most of which are relatively small and of low mass. The members of the Sco OB 2 association and the X-ray detected pre–main-sequence stars (PMSs) are distributed all around this region. The OB stars and the molecular clouds show exclusive distributions. Large fractions of the PMSs are located away from the molecular clouds, and are thus isolated. The origin of the isolated PMSs is discussed. About 40% of the PMSs have candidates of their parent clouds less massive than 20 $M_\odot$ within 4 pc, which suggests in-situ star formation in the small clouds and their rapid dissipation. The separations from the PMSs to the clouds are typically larger than those in the Chamaeleon region, probably because of coexisting OB stars. From the cloud structures and the distributions of the OB stars, PMSs, and H I expanding shell, it is suggested that the molecular clouds have been effectively dissipated by the OB stars and a shock wave, which may also have triggered star formation in Lupus and the ρ Oph clouds.

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://casa.colorado.edu/reipurth or at http://www.eso.org/gen-fac/pubs/starform/ .

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.

New Jobs

FACULTY POSITION - SUB-MILLIMETER ARRAY ASTROPHYSICS

The Institute for Astronomy (IfA) at the University of Hawai'i invites applications for a state-funded, tenure-track faculty position (pending position approval). The appointment could be at the Assistant, Associate, or Full Astronomer level depending on the qualifications and experience of the candidate. Preference will be given to candidates with the expertise to exploit the Sub-Millimeter Array telescope (SMA) on Mauna Kea in pursuit of science goals related to NASA's "Origins" themes. The University of Hawai'i has 15time on the SMA, scheduled to be in operation in early 2002. The individual chosen is expected to conduct a first-class research program in astronomy, teach one undergraduate or graduate course per year and participate in the academic and scientific life of the IfA. Minimum Qualifications: Ph.D. in astronomy or physics, demonstrated research excellence and teaching ability. Additionally, at the Associate level: four years at the Assistant level or equivalent; at the Astronomer level: four years experience at the Associate level or equivalent. The expected starting date is July 2002. The salary will be commensurate with qualifications and experience. To apply applicants should submit a curriculum vitae, bibliography, and a description of research interests to Dr. Rolf Kudritzki, Director, Institute for Astronomy, 2680 Woodlawn Drive, Honolulu, HI 96822. Applicants should arrange for three letters of recommendation to be sent to the above address. Closing date: January 15, 2001. For additional information, please see our website: www.ifa.hawaii.edu, call Dr. Kudritzki at 808-956-8566 (FAX 808-946-3467) or send email to kud@ifa.hawaii.edu. The University of Hawai'i is an EEO/AA employer.

Research Associate/Assistant Astronomer
Steward Observatory, The University of Arizona

E-mail contact: mmeyer@as.arizona.edu

Steward Observatory at the University of Arizona invites applications for positions in support of the SIRTF Legacy Science Program *"Formation and Evolution of Planetary Systems"* led by Michael Meyer. The science goals of this project are to: 1) characterize the transition from primordial dust to debris disk systems; 2) constrain the timescale of gas disk dissipation; and 3) examine the diversity of planetary system architectures. Candidates will be expected to contribute to the reduction and analysis of infrared data collected with SIRTF as well as ground-based ancillary observing projects and must have a Ph.D. in Astronomy or related field. Demonstrated experience in infrared astronomy, related fields of star and planet formation, and/or IDL-based scientific software is desirable.

Successful candidates will have full access to the facilities of Steward Observatory including the 6.5m MMT and Magellan telescopes, the 2.3m Kitt Peak Bok telescope, and the Heinrich-Hertz Sub-millimeter Telescope on Mt. Graham. For more information, please visit the project WWW site at: http://gould.as.arizona.edu/feps.

The positions can be at the Research Associate or at the Assistant Astronomer level at Steward Observatory, at salaries from $38,000 to$ 47,000 depending on qualifications and experience. Review of materials will begin February 1, 2002 and will continue until the positions are filled. Please send a curriculum vitae, statement of experience and research interests, and the names of three references to Ms. Debra Wilson at the above address or apply via email to: dwilson@as.arizona.edu.

The University of Arizona is an EEO/AA Employer-M/W/D/V.

http://gould.as.arizona.edu/feps

PH.D. POSITION (AIO)
MOLECULAR GAS IN CENTERS OF GALAXIES

Supervision: Dr. F.P. Israel (Leiden University), Dr. P.P. van der Werf (Leiden University), and Dr. M. Spaans (University of Groningen)

Applications are invited (*deadline January 31, 2002)* for a Ph.D. position at the Leiden Observatory, available any time starting early 2002, for research into the nature and origin of molecular gas concentrations in the centers of galaxies,

Many late-type spiral galaxies contain significant amounts of molecular gas at distances of less than a kiloparsec from their nucleus. Much of this gas is dense and warm, and occurs in the form of clouds and filaments. The central gas concentrations are thought to result from the loss of angular momentum of disk material caused by bar-like potentials, close galactic encounters or mergers. In turn, these central concentrations may play a role in extragalactic nuclear and and circumnuclear activity, such as the occurrence of circumnuclear starbursts and infalling material triggering nuclear activity ('feeding the monster').

This research aims at constructing consistent models of circumnuclear molecular gas, to place these models in the context of theories explaining the origin of such concentrations and and to explore their role in nuclear activity. It will blend theory and observation, but emphasize theoretical work.

At Leiden, models have already been developed to calculate the physical and chemical structure of interstellar clouds and circumstellar shells in the Milky Way. Building on the work already accomplished, the Ph.D student will expand the existing molecular-excitation models to include inhomogeneous media; most of the building blocks are already available. A further expansion to include ensembles of clouds will open up the possibility to calculate the physical and chemical structure of extragalactic circumnuclear regions, in terms of their carbon/carbon monoxide network properties. Models will be constrained by the now abundantly available observational material, If needed, further observational material may be gathered at the UK-NL telescopes (JCMT and La Palma), ESO telescopes or other facilities to which the Observatory has access.

Leiden is a pleasant university town, situated in the heart of the Netherlands with excellent connections to the rest of Europe. The Leiden Observatory offers a stimulating work environment with considerable expertise on both the theoretical and the observational parts of the program (see http://www.strw.leidenuniv.nl for more detailed information about Leiden Observatory).

Applicants should have obtained, or be about to obtain, a Masters degree or its equivalent in astronomy or physics. They should include a curriculum vitae, a comprehensive list of academic achievements (including grades) and names and adresses of two references.

Please apply to:
Dr. F.P. Israel
Sterrewacht Leiden
P.O Box 9513
2300 RA Leiden
Netherlands
e-mail: israel@strw.leidenuniv.nl

Osservatorio Astronomico di Palermo
Giuseppe S. Vaiana

Marie Curie Fellowships
Closing date: 15 January 2002

Osservatorio Astronomico di Palermo (OAPA) Giuseppe S. Vaiana expects to appoint one fellow in the area of X-ray Astrophysics under the European Commission's Marie Curie Development Host Fellowship Scheme in one of the following areas:

- Analysis and interpretation of X-ray observations. The successfull candidate is expected to partecipate to the analysis of new XMM/Newton and/or Chandra observations of star forming regions and stellar open clusters, as part of the program of the OAPA on the study of the evolution of stellar coronal emission and stellar populations.
- Low temperature spectroscopic X-ray detectors for laboratory and astrophysical plasmas The succesfull candidate is expected to partecipate to the development, testing and optimization of cryogenic detectors at the X-ray Astronomy Calibration and testing (XACT) facility of OAPA.

The fellowship will start before the end of July 2002.

Candidates should have a PhD in a relevant field or at least four years of full-time research experience at postgraduate level other than doctoral studies, the ability to work in team.

The applicant must be national of a Member State of the European Community (other than Italy) or an Associated State, or otherwise residing in the Community for at least the last five years. The fellow must be of age 35 years or less (allowance is made for time actually served in compulsory military or civil service and for childcare with a maximum of 2 years per child). Candidates should not have been resident in Italy for more than 12 months in the two years prior to selection. Gross salary, including all compulsory deductions under italian legislation, is fixed at 3813 Euro per month plus a mobility allowance for the duration of the contract, which is expected to last for 24 months. Female candidates are explicitly encouraged to apply.

Applications, including CV, publication list, description of applicant's research interests/program (all documents above should be signed by the candidate), documents certifying the doctoral degree or a four years of full time research experience and two letters of recommendations should arrive by 15 January 2002 at:

Osservatorio Astronomico di Palermo
Marie Curie Fellowship Selection
Piazza del Parlamento 1
I-90134 Palermo, Italy

For further information contact:
Giusi Micela - giusi@oapa.astropa.unipa.it or http://www.astropa.unipa.it

POSTDOC POSITION - MHD models of astrophysical outflows

The University of Rochester Department of Physics and Astronomy invites applications for a postdoctoral research associate position in computational astrophysics. Strong candidates with experience in all forms of computational astrophysics will be considered. The position can be filled immediately though the candidate must have a Ph.D. in Astronomy, Physics, or a related field at the time he or she begins.

The successful applicant will join a program, led by Adam Frank and Eric Blackman to develop MHD models of astrophysical outflows. This position is jointly funded by the University of Rochester's Laboratory for Laser Energetics (LLE). The LLE is an inertial confinement fusion research facility and is home of the Omega Laser system, currently the world's most powerful laser. The LLE also houses extensive parallel computational resources. The applicant will have 30

The appointment will be for three years, subject to availability of funding and suitable performance on the part of the appointee. To apply, please submit a CV, a list of publications, and a statement of research interests and accomplishments and have three letters of reference in support of the candidate sent directly to Professor Adam Frank at the above below. The application review process will continue until the position is filled. AAE/EOE

Attention: Adam Frank, Professor
Department of Physics and Astronomy
UNIVERSITY OF ROCHESTER
Rochester, NY 14627-0171, USA

Tel: 716-275-1717 – FAX: 716-273-2813

afrank@pas.rochester.edu – www.pas.rochester.edu

POSTDOCTORAL POSITION

PAUL SCHERRER INSTITUTE
SWITZERLAND

We invite applications for a postdoctoral research position in stellar astrophysics, starting in summer or fall 2002. This position is initially awarded for up to three years, with the possibility of extension. We are particularly looking for candidates with a background in one or more of the following fields: (i) star formation and young stars, observations and/or theory; (ii) magnetic activity/coronal physics of young and active stars (X-rays, radio); or (iii) theory of coronal plasmas. Candidates with expertise in related fields of stellar astronomy (any observational wavelength regime) are also invited to apply.

The successful candidate has a doctoral degree and will work in a joint team of astronomers from PSI and ETH Zurich. This team has a strong background and interest in high-energy astrophysics, X-ray and radio astronomy, magnetically active and young stars, plasma physics, and solar physics. The institutes are/were involved in the development of the XMM-Newton, Hessi, and Integral missions. We offer extensive collaborations within ongoing XMM-Newton guaranteed/open time and Chandra GO projects, and within our stellar VLA/VLBA/VLBI campaigns. The candidate is expected to develop further vigorous research activities. Office space and computing facilities will be provided by both PSI and ETH.

Please send CV, publication list, and a short description of research interests plans, and arrange for two letters of recommendation sent directly to us. Applications are requested by 1 February 2002 but will continue to be considered thereafter until the position is filled. For questions, please send e-mail to Dr. M. Güdel (guedel@astro.phys.ethz.ch).

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

Meetings

Chemistry As A Diagnostic Of Star Formation

21–23 August 2002
University of Waterloo, Ontario, Canada
Conference website: http://astro.uwaterloo.ca/sfchem2002
Registration opens February 1, 2001

An understanding of the microphysics underlying spectral line and continuum observations is essential to most areas of astronomy. In star formation, where optical measurements are often lacking, our dependence on these diagnostics is particularly acute. Improvements in single-dish and interferometer (sub-)millimeter facilities, both ground- and space-based, continue to provide a wealth of new data. These observations reveal a wide range of physical conditions ranging from the cold, pre-collapse stage, where key molecules are depleted onto grains, to warmer, more evolved phases where ices evaporate and drive a rich chemistry. As our only window onto the gas and solid-state composition of star-forming regions, interpretation of these data is critical to many important problems in the field.

The aim of the meeting is to forge a synthesis between the different domains of star formation research via the unifying concept of astrochemistry. This should help turn spectroscopy and broadband photometry into even more powerful probes of the physical transformation of gas and dust into stars. By concentrating on the role of dust and gas, we hope to provide a more focussed forum for discussion of the critical problems and directions of progress, while maintaining an informal, workshop environment.

Scientific Program

I. Fundamental processes: Gas-grain chemistry, photochemistry, and excitation. Energy balance, heating and cooling. Properties and influence of dust grains. Production/destruction and abundance of key molecules, including H_2. New diagnostics from laboratory and theoretical chemistry.

II. Chemistry, physical conditions, and structure of dark clouds: Chemical evolution of molecular clouds. Models vs. observations of molecular cloud structure. Depletion of molecular species. Ionization fraction and magnetic fields. Consequences of turbulence for chemistry.

III. Chemical diagnostics of infall, outflow, and disks: Chemical signatures of infall. Chemical signatures of outflow. Comparison of low- and high-mass environments. Production/destruction of molecules/dust in infall/outflows. Chemical and kinematic signatures of disks. Spectral energy distributions.

IV. High-mass star formation: Role of photoionization and shocks. Ultracompact HII regions and hot cores. Masers. Dust production and destruction.

V. The role of dust continuum observations: Inferred properties of dense cores. Dust-to-gas ratio. Line contamination of continuum observations.

VI. Issues of ongoing and future interest: Primordial star formation. Spectroscopic signatures of brown dwarfs and extrasolar planets. Observatories, telescopes, instrumentation, and future missions.

Scientific Organizing Committee: M. Fich (Waterloo, Chair), C. Curry (Waterloo), E. van Dishoeck (Leiden), D. Williams (UC London), A. Tielens (Kapteyn Inst.), N. Evans (Texas), E. Bergin (CfA).

Local Organizing Committee: C. Curry (Chair), M. Fich, W. Duley, P. Bernath (Waterloo).

A more detailed announcement may be found at the conference website:

`http://astro.uwaterloo.ca/sfchem2002/`

At this time, we would like to hear from those interested in participating. If you would like to receive future mailings, please send a short message to: `sfchem@astro.uwaterloo.ca`

Debris Disks and the Formation of Planets: A Symposium in Memory of Fred Gillett

Thursday - Saturday, April 11-13, 2001, University Park Marriott, Tucson, Arizona

Program outline:
1. History of the discovery
2. Progenitors
3. Debris disks
4. Descendants, and connection to the Solar System
5. Prospects: observational and theoretical

Chairs of the Scientific Organizing Committee:
Dana Backman dana@maunakea.fandm.edu 717-291-4132
Larry Caroff lcaroff@attbi.com 408-735-8990

Chair of the Local Organizing Committee:
Steve Strom sstrom@noao.edu, 520-318-8000

http://www.noao.edu/meetings/gillett/