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Abstracts of recently accepted papers

VLA Detection of the Exciting Sources of the Molecular Outflows Associated with L1448 IRS2, IRAS 05327+3404, L43, IRAS 22142+5206, L1211, and IRAS 23545+6508

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We present sensitive VLA observations at 3.6-cm of nine fields containing molecular outflows. We detected candidates for the exciting sources of the molecular outflows in six of the fields: L1448 IRS2, IRAS 05327+3404, L43, IRAS 22142+5206, L1211, and IRAS 23545+6508. We discuss the parameters of these sources, as well as their relation with sources detected at other wavelengths.

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<http://www.astrosmo.unam.mx/~l.rodriquez/publ.html>

IRAS 05358+3543: Multiple outflows at the earliest stages of massive star formation

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We present a high-angular-resolution molecular line and millimeter continuum study of the massive star formation site *IRAS* 05358+3543. Observations with the Plateau de Bure Interferometer in CO 1–0, SiO 2–1 and H¹³CO⁺ 1–0 reveal at least three outflows which cannot be separated in single-dish data. Observations at millimeter and sub-millimeter wavelengths from the IRAM 30 m telescope and the CSO provide additional information on the region. The most remarkable feature is a highly collimated (collimation factor ~ 10) and massive ($> 10 M_{\odot}$) bipolar outflow of ~ 1 pc length, which is part of a quadrupolar outflow system. The three observed molecular outflows forming the *IRAS* 05358+3543 outflow system resemble, in structure and collimation, those typical of low-mass star-forming regions. They might therefore, just like low-mass outflows, be explained by shock entrainment models of jets. We estimate a mass accretion rate of $\sim 10^{-4} M_{\odot}/\text{yr}$, sufficient to overcome the radiative pressure of the central object and to build up a massive star, lending further support to the hypothesis that massive star formation occurs similarly to low-mass star formation, only with higher accretion rates and energetics. In the millimeter continuum, we find three sources near the center of the quadrupolar outflow, each with a mass of 75–100 M_{\odot} . These cores are associated with a complex region of infrared reflection nebulosities and their embedded illuminating sources. The molecular line data show that SiO is found mostly in the outflows, whereas H¹³CO⁺ traces core-like structures, though likely with varying relative abundances. Thermal CH₃OH comprises both features and can be disentangled into a core-tracing component at the line center, and wing emission following the outflows. A CO line-ratio study (using data of the

$J = 1 - 0, 2 - 1$ & $6 - 5$ transitions) reveals local temperature gradients.

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Preprints available at <http://www.mpifr-bonn.mpg.de/staff/beuther/>

Stellar Metallicity and the Formation of Extrasolar Gas Giant Planets

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Spectroscopic searches for extrasolar planets are most successful when the target star has high metallicity, a trend that could be caused by observational selection effects, pollution by ingested planetary material, or a requirement of high metallicity for gas giant planet formation. We show that in the scenario of the disk instability mechanism for forming gas giant protoplanets, clump-forming gravitational instabilities proceed in much the same manner in protoplanetary disks with metallicities that vary by factors of 10 greater or less than that of a standard disk model. This remarkable insensitivity to the dust grain opacity is attributed to radiative energy losses from the disks being controlled more by their being embedded in a thermal bath determined by their central protostar, than by radiative fluxes deep within the disks' optically thick midplanes. This result suggests that if disk instability is the primary formation mechanism for extrasolar gas giant planets, even relatively low-metallicity, galactic disk stars should harbor gas giant planets.

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

Formation Pumping of Molecular Hydrogen in the Messier 17 Photodissociation Region

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We have imaged the emission from the near-infrared $v=1-0$ S(1), $1-0$ S(7), $2-1$ S(1) and $6-4$ O(3) lines of molecular hydrogen in the N- and SW-Bars of M 17, together with the hydrogen Br γ and Br10 lines. This includes the first emission line image ever to be obtained of a line from the highly excited $v=6$ level of molecular hydrogen. In both Bars, the H₂ emission is generally distributed in clumps along filamentary features. The $1-0$ S(1) and $2-1$ S(1) images have similar morphologies. Together with their relative line ratios, this supports a fluorescent origin for their emission, within a photodissociation region. The SW-Bar contains a clumpy medium, but in the N-Bar the density is roughly constant. The $1-0$ S(7) line image is also similar to the $1-0$ S(1) image, but the $6-4$ O(3) image is significantly different to it. Since the emission wavelengths of these two lines are similar (1.748 to 1.733 μ m), this cannot be due to differential extinction between the $v=6$ and the $v=1$ lines. We attribute the difference to the pumping of newly formed H₂ into the $v=6$, or to a nearby, level. However, this also requires either a time-dependent photodissociation region (where molecule formation does not balance dissociation), rather than it to be in steady-state, and/or for the formation spectrum to vary with position in the source. If this interpretation of formation pumping of molecular hydrogen is correct, it is the first clear signature from this process to be seen.

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Preprints available via www.phys.unsw.edu.au/mgb/Bibliography/bibliography.html

Dense Cores in Dark Clouds. XIV. $\text{N}_2\text{H}^+(1-0)$ maps of dense cloud cores

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We present results of an extensive mapping survey of $\text{N}_2\text{H}^+(1-0)$ in about 60 low mass cloud cores already mapped in the $\text{NH}_3(1,1)$ inversion transition line. The survey has been carried out at the FCRAO antenna with an angular resolution of $54''$, about 1.5 times finer than the previous ammonia observations made at the Haystack telescope. The comparison between N_2H^+ and NH_3 maps shows strong similarities in the size and morphology of the two molecular species indicating that they are tracing the same material, especially in starless cores. Cores with stars typically have map sizes about a factor of two smaller for N_2H^+ than for NH_3 , indicating the presence of denser and more centrally concentrated gas compared to starless cores. The mean aspect ratio is ~ 2 . Significant correlations are found between NH_3 and N_2H^+ column densities and excitation temperatures in starless cores, but not in cores with stars, suggesting a different chemical evolution of the two species. Starless cores are less massive ($\langle M_{\text{vir}} \rangle \simeq 3 M_{\odot}$) than cores with stars ($\langle M_{\text{vir}} \rangle \simeq 9 M_{\odot}$). Velocity gradients range between 0.5 and 6 km/s/pc, similar to what has been found with NH_3 data, and the ratio β of rotational kinetic energy to gravitational energy have magnitudes between $\sim 10^{-4}$ and 0.07, indicating that rotation is not energetically dominant in the support of the cores. “Local” velocity gradients show significant variation in both magnitude and direction, suggesting the presence of complex motions not interpretable as simple solid body rotation. Integrated intensity profiles of starless cores present a “central flattening” and are consistent with a spherically symmetric density law $n \propto r^{-\alpha}$ where $\alpha = 1.2$ for $r < r_{\text{break}}$ and $\alpha = 2$ for $r > r_{\text{break}}$, where $r_{\text{break}} \sim 0.03$ pc. Cores with stars are better modelled with single density power laws with $\alpha \geq 2$, in agreement with observations of submillimeter continuum emission. Line widths change across the core but we did not find a general trend: there are cores with significant positive as well as negative linear correlations between Δv and the impact parameter b . The deviation in line width correlates with the mean line width, suggesting that the line of sight contains ~ 10 coherence lengths. The corresponding value of the coherence length, ~ 0.01 pc, is similar to the expected cutoff wavelength for MHD waves. This similarity may account for the increased “coherence” of line widths on small scales. Despite of the finer angular resolution, the majority of N_2H^+ and NH_3 maps show a similar “simple” structure, with single peaks and no elongation.

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<http://arXiv.org/ps/astro-ph/0202173>

<http://www.arcetri.astro.it/~starform/publ2002.htm>

Deuterium fractionation on interstellar grains studied with modified rate equations and a Monte Carlo approach

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The formation of singly and doubly deuterated isotopomers of formaldehyde and of singly, doubly, and multiply deuterated isotopomers of methanol on interstellar grain surfaces has been studied with a semi-empirical modified rate approach and a Monte Carlo method in the temperature range 10-20 K. Agreement between the results of the two methods is satisfactory for all major and many minor species throughout this range. If gas-phase fractionation can produce a high abundance of atomic deuterium, which then accretes onto grain surfaces, diffusive surface chemistry can produce large abundances of deuterated species, especially at low temperatures and high gas densities. Warming temperatures will then permit these surface species to evaporate into the gas, where they will remain abundant for

a considerable period. We calculate that the doubly deuterated molecules CHD_2OH and CH_2DOD are particularly abundant and should be searched for in the gas phase of protostellar sources. For example, at 10 K and high density, these species can achieve up to 10-20% of the abundance of methanol.

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On the source of the flaring activity in AB Doradus: the UV spectral signatures

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AB Dor is a young, 30 Myrs old, low mass star with a short rotation period and strong flaring activity. In this work, a detailed analysis of the flaring activity is carried out based on ultraviolet spectral tracers of hot ($T \sim 10^5$) plasma namely, HST/GHRS profiles of the C IV[UV1] and Si IV[UV1] lines. The quiescent component has been subtracted out and the spectral signature of the flares is analyzed in detail. A total amount of nine events are detected in 10.63 hours. The e-folding time for flares has been derived when possible, finding out values in between 300 and 1200 seconds. It is shown that the C IV[UV1] and Si IV[UV1] profiles associated with the flaring activity can be classified into three main groups: narrow redshifted profiles, “broad” profiles and double peaked profiles. Therefore, the spectroscopic signature of flares in hot ($T \sim 10^5\text{K}$) plasma is not always the same. As a consequence, it is highly likely that different mechanisms are involved in the flaring activity of AB Dor.

The most frequently observed profiles are the narrow redshifted profiles; 6 out of the 9 events display this type of profile. An analysis of the velocity field at the stellar surface shows up that they are most likely associated with matter infall. Henceforth, it is feasible that this type of flares are associated with downward flowing material in *postflare magnetic loops*, as frequently observed in the Sun.

The broad profiles have a FWHM $\simeq 300 \text{ Km s}^{-1}$ and are very asymmetric with an extended bluewing reaching 400 Km s^{-1} . These profiles have been observed during the strongest flare in the monitoring when the line flux rose up to 3 times the quiescent value. The large width and asymmetry of the profiles is best explained if this type of flares are associated with gas flows in curved magnetic structures. Three possible mechanisms are analyzed: (1) the development of thermal instabilities in large magnetic loops, (2) gas infall and (3) the interaction between the fast and slow components of the stellar wind. The last mechanism seems to be the most feasible given the short duration of the flares.

Finally, a possible absorption caused by the hot component of “sling-shot” prominences has been searched for in the C IV[uv1] and Si IV[uv1] profiles. Two of the three strongest $\text{H}\alpha$ prominences (A and H) seem to have been detected. The most compelling evidence corresponds to A, when an absorption component is observed moving from blue to redshifted velocities from $\phi = 10440.978$ to $\phi = 10441.010$. The strength of the absorption at $\phi = 10441.010$ is $0.2 \times 10^{-12} \text{ erg s}^{-1} \text{ cm}^{-2}$ and has a FWHM = 86 Km s^{-1} .

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The disk wind in young binaries and its influence on the infrared excesses of young stars

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An influence of the binarity of young stars on the spectral energy distribution of the infrared radiation of the circumstellar dust has been considered. It is shown that in the binaries with the low mass secondary component a disk wind of the latter plays an important role in the formation of the common envelope. The wind velocities in the winds’s periphery are such that the matter of the wind can be partly or completely captured by the primary component of

the system even if the distance between companions is about of several astronomical units. As a result, a rather complex, from the point of view of spatial and kinematical properties, envelope appears. The mass of this envelope is substantially small compared to that of the accretion disk surrounding the binary system. Nevertheless, a thermal radiation from the dust grains in this envelope can make a contribution comparable with that of all of the accretion disk. We discuss this result in the context of the problem of the near - IR (2 - 10 μm) radiation deficit existing in the modern models of accretion disks of young stars.

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Observation of an unique minimum of RR Tau in the optical and near-infrared spectral regions

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The results of observations of the UX Ori type star RR Tau in the optical (UBVRI) and near-infrared (JHKLM) spectral regions made from November 2000 to April 2001 are presented. During the observations it has been registered the long lasting (about half a year) Algol-type minimum with amplitude $\Delta V \approx 2.9$. The decrease of the optical fluxes of RR Tau was accompanied with the increase of the linear polarization typical for UX Ori type stars, testifying to the eclipsing nature of the minima. The fluxes in two infrared (IR) bands J and H changed synchronously with those in the optical ones while those in the K and L bands showed the opposite tendency: during the optical minimum the stellar flux in these two bands increased. The observations of RR Tau in the M band were not accurate enough (about 0.1 of the stellar magnitude) and were not used in the analysis.

An analysis of the observations showed that the dust cloud moving at the distance of about 1 AU from the star became the source of the radiation in the K and L bands. An increase of the flux in these bands was caused not by an increase of the dust temperature but due to an increase of the total number of the emitting particles in the cloud. The reason for this could be either a real increase of the number of small particles in the cloud due to sublimation and destruction of the larger ones or the deformation and destruction of the cloud itself under the effect of the tidal perturbations and, as a result, a penetration of the stellar radiation in the innermost dense parts of the cloud with their subsequent heating.

We used the fluxes observed in the L band to estimate the mass of the radiating dust in the cloud: $\approx 10^{23}$ g. If we consider that besides the dust heated by the radiation of the star there is the cold dust in the cloud and adopt the dust/gas ratio as in the interstellar medium (1:100), then the total mass of the cloud will be $\geq 10^{25}$ g. According to this value and also to the duration of the minimum we observed a rather rare episode when the giant gas and dust cloud with the total mass of 0.1 Moon's mass or even more passed very close to the young star (and, probably, fell onto it).

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Limits on Radio Continuum Emission from a Sample of Candidate Contracting Starless Cores

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We used the NRAO Very Large Array to search for 3.6 cm continuum emission from embedded protostars in a sample

of 8 nearby “starless” cores that show spectroscopic evidence for infalling motions in molecular emission lines. We detect a total of 13 compact sources in the eight observed fields to 5σ limiting flux levels of typically 0.09 mJy. None of these sources lie within $1'$ of the central positions of the cores, and they are all likely background objects. Based on an extrapolation of the empirical correlation between the bolometric luminosity and 3.6 cm luminosity for the youngest protostars, these null-detections place upper limits of $\sim 0.1 L_{\odot}(d/140 \text{ pc})^2$ on the luminosities of protostellar sources embedded within these cores. These limits, together with the extended nature of the inward motions inferred from molecular line mapping (Lee et al. 2001), are inconsistent with the inside-out collapse model of singular isothermal spheres and suggest a less centrally condensed phase of core evolution during the earliest stages of star formation.

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Smoothed Particle Hydrodynamics with particle splitting, applied to self-gravitating collapse

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We describe and demonstrate a method for increasing the resolution locally in a Smoothed Particle Hydrodynamic (SPH) simulation, by splitting particles. We show that in simulations of self-gravitating collapse (of the sort which are presumed to occur in star formation) the method is stable, and affords great savings in computer time and memory. When applied to the standard Boss & Bodenheimer test – which has been shown to depend critically on fulfilment of the Jeans Condition – the results are comparable both with those obtained using Adaptive Mesh Refinement, and with those obtained using a standard high-resolution SPH simulation, but they are achieved with considerably less computational resource. Further development and testing is required before the method can safely be applied to more general flows.

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HST/WFPC2 Images of the GG Tauri Circumbinary Disk

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We present the first visible wavelength images of the GG Tauri circumbinary ring, obtained with the Hubble Space Telescope’s Wide Field and Planetary Camera 2. Scattered light from the ring is detected in both V and I band images. The images show that the ring is smooth, except for a small gap that could be a shadow caused by material between the stars and the ring. The spokes seen extending from the stars to the ring in ground-based adaptive optics images are not seen in our data, which suggests that they may be image artifacts. The nearside/farside surface brightness ratio is 6.9 in I band, consistent with forward scattering by small dust grains. The azimuth of the peak ring surface brightness appears offset by 13° from the azimuth closest to us, as seen in previous near-IR HST observations. This may indicate that the ring is warped or somehow shadowed by the circumstellar disks. The color of the ring is redder than the combined light from the stars as observed by HST, confirming previous measurements that indicate that circumstellar disks may introduce extinction of light illuminating the ring. We detect a bright, compact arc of material $0.3''$ from the secondary star at an azimuth opposite the primary. It appears to be too large to be a circumstellar disk and is not at the expected location for dust trapped at a Lagrange point.

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Strong emission-line stars identified toward the Rosette Nebula

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Several strong emission line stars were found in the optical identification of the ROSAT PSPC sources in the Rosette Nebula. These possible X-ray emitters were classified from the low-resolution spectra obtained as Herbig Ae/Be type stars or probable weak-line T Tauri stars. A classical Be star was also identified around one of the X-ray sources studied. Our study supports the conjecture that ROSAT X-ray observations could trace low- and intermediate-mass star formation to a distance of ~ 1.5 kpc.

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H α Emission Stars and Herbig-Haro Objects in the Vicinity of Bright-Rimmed Clouds

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Bright-rimmed clouds (BRCs) found in HII regions are probably sites of triggered star formation due to compression by ionization/shock fronts. Many BRCs harbor IRAS point sources of low dust temperature. They also frequently contain a small cluster of near-IR stars, that is elongated along the axis of the BRC.

Here we present the results of our H α grism spectroscopy and narrow-band imaging observations of BRCs in search of candidate pre-main sequence stars of the T Tauri, Herbig Ae/Be and related types, and of Herbig-Haro (HH) objects. We have detected a large number (460) of H α emission stars down to a limiting magnitude of about $R = 20$, in and around all but two of the 28 BRCs observed. The present study has, for the first time, reached down nearly to the faintest classical TTS population in OB associations. Twelve new HH objects have been found. Most are of small apparent size, emphasizing the need for deep searches at high spatial resolution, but HH 588 associated with BRC 37 represents a huge HH complex composed of two-staged bow shocks on both sides of a tiny central knot. These stars and HH objects are concentrated near the tip of bright rims (ie. in the head of the BRCs and just outside the rims) and often make loose aggregates similar to those of near-IR stars, thus supporting our hypothesis of “small-scale sequential star formation”. The presence of such a large number of H α emission stars in the immediate vicinities of BRCs implies that second-generation formation of low-mass stars is relatively extensive, and further supports the notion of cohabitation of high- and low-mass populations in OB association.

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<http://www.nsc.nagoya-cu.ac.jp/~sugitani/preprints/ogura.pdf> (14MB)

Extended Near-Infrared Emission from Candidate Protostars in the Taurus-Auriga Molecular Cloud

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We describe near-IR imaging data for a sample of 23 class I sources in the Taurus-Auriga dark clouds. Combining our data with previous photometry, we detect brightness variations of ~ 0.1 – 0.5 mag in many sources. The near-IR morphologies are consistent with mm continuum measurements. Most ($\sim 60\%$) of the sample are true protostars; the

rest may be objects in transition between class I and class II, T Tauri stars with edge-on disks, or heavily reddened T Tauri stars.

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Flux-Velocity Relation for H₂ Outflows

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We present an analysis of velocity resolved near-IR molecular hydrogen observations of a variety of protostellar outflows with very different energetics, degrees of collimation and morphologies. Observations in the 2.12 μm line of H₂ were obtained using an IR Fabry-Pérot interferometer with a spectral resolution of 23 km s⁻¹. The integrated flux-velocity diagrams for each outflow show a flat spectrum for low velocities followed by a decreasing power law $dF/dv \propto v^\gamma$, with γ between -1.8 and -2.6, for velocities higher than a clearly defined break velocity at 2 to 17 km s⁻¹. Contrary to shock model predictions it is shown that the H₂ intensity is constant with velocity. We argue that the flux-velocity relation can then be interpreted as a mass-velocity relation, in striking similarity to the power law mass spectra observed in CO outflows. By comparing H₂ and CO mass-velocity spectra, it is shown that there is a velocity regime where both molecules coexist and produce similar γ values. Evolution effects in outflows show as a correlation between outflow length and γ , as outflows age the spectra becomes steeper. Our results support a common physical origin for both CO and H₂ emission and a strong association between the molecular outflows traced in each molecule.

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Preprint available at: <http://bufadora.astroesen.unam.mx/salas/h2mvrel.ps>

HeI 1.083 μm emission and absorption in DG Tauri: line excitations in the jet, hot wind, and accretion flow

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We present long-slit spectroscopy and spectro-astrometry of HeI 1.083 μm emission in the T Tauri star, DG Tauri. We identify three components in the HeI feature: (1) a blueshifted emission component at $v \simeq -200$ km s⁻¹, (2) a bright emission component at zero-velocity with a FWZI of ~ 500 km s⁻¹, and (3) a blueshifted absorption feature at velocities between -250 and -500 km s⁻¹. The position and velocity of the blueshifted HeI emission coincide with a high-velocity component (HVC) of the [FeII] 1.257 μm emission, which arises from a jet within an arcsecond of the star. The presence of such a high excitation line (excitation energy ~ 20 eV) within the jet supports the scenario of shock heating. The bright HeI component does not show any spatial extension, and it is likely to arise from magnetospheric accretion columns. The blueshifted absorption shows greater velocities than that in H α , suggesting that these absorption features arise from the accelerating wind close to the star.

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Light scattering by an elongated particle: spheroid versus infinite cylinder

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Using the method of separation of variables and a new approach to calculations of the prolate spheroidal wave functions, we study the optical properties of very elongated (cigar-like) spheroidal particles.

A comparison of extinction efficiency factors of prolate spheroids and infinitely long circular cylinders is made. For the normal and oblique incidence of radiation, the efficiency factors for spheroids converge to some limiting values with an increasing aspect ratio a/b provided particles of the same thickness are considered. These values are close to, but do not coincide with the factors for infinite cylinders. The relative difference between factors for infinite cylinders and elongated spheroids ($a/b \gtrsim 5$) usually does not exceed 20% if the following approximate relation between the angle of incidence α (in degrees) and the particle refractive index $m = n + ki$ takes the place: $\alpha \gtrsim 50|m - 1| + 5$ where $1.2 \lesssim n \lesssim 2.0$ and $k \lesssim 0.1$.

We show that the quasistatic approximation can be well used for very elongated optically soft spheroids of large sizes.

Accepted by Measurement Science and Technology

Preprint: astro-ph/0201548

Multiple scattering of polarized radiation by non-spherical grains: first results

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We present the first numerical radiative transfer simulation of multiple light scattering in dust configurations containing aligned non-spherical (spheroidal) dust grains. Such models are especially important if one wants to explain the circular polarization of light, observed in a variety of astronomical objects. The optical properties of the spheroidal grains are calculated using the method of separation of variables developed by Voshchinnikov & Farafonov (1993). The radiative transfer problem is solved on the basis of the Monte Carlo method. Test simulations, confirming the correct numerical implementation of the scattering mechanism, are presented. As a first application, we investigate the linear and circular polarization of light coming from a spherical circumstellar shell. This shell contains perfectly aligned prolate or oblate spheroidal grains. We investigate the dependence of the results on the grain parameters (equivolume radius, aspect ratio) and the shell parameters (inner/outer radius, optical thickness). The most remarkable features of the simulated linear polarization maps are so-called polarization null points where the reversal of polarization occurs. They appear in the case when the grain alignment axis is perpendicular to the line of sight. The position of these points may be used for the estimation of grain shape and geometrical structure of the shell. The origin of null points lies in the physics of light scattering by non-spherical particles and is not related to the cancellation of polarization as was discussed in previous models. The maps of circular polarization have a sector-like structure with maxima at the ends of lines inclined to the grain alignment axis by $\pm 45^\circ$.

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Dissertation Abstracts

Coronal activity in the first phases of stellar evolution

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I have approached the problem of coronal activity in the first stages of stellar evolution, from the early PMS (~ 1 Myr.) to the ZAMS (~ 100 Myr.) from a mainly observational standpoint. I describe the analysis of X-ray observations of three young clusters. In order of age: the Orion Nebula Cluster (ONC, ~ 1 Myr.), NGC 2264 (~ 3 Myr.) and NGC 2516 (~ 140 Myr.). The first and the last are observed with *Chandra*, NGC 2264 with *ROSAT*.

In the ONC I find no correlation between activity and stellar rotation. Instead I observe that median L_X correlates with mass, from the *brown dwarf* regime, ($M = 0.03 - 0.08 M_\odot$, $\text{Log}(L_X) \sim 10^{28}$ ergs s $^{-1}$) to about $3 M_\odot$ ($\text{Log}(L_X) \gtrsim 10^{31}$) and then drops for stars that, according to models, do not have a convective region. The relation of L_X with mass can be also imputed to the fact that most stars have $\text{Log}(L_X/L_{bol})$ close, even though on average lower, to the *saturation* value (~ -3) and to the direct relation between L_{bol} and mass for stars of a given age. I observe that median $\text{Log}(L_X/L_{bol})$ also increases with mass by about 0.4 dex for $0.1 \lesssim M \lesssim 0.5 M_\odot$. A dependence of L_X and L_X/L_{bol} on circumstellar accretion and/or presence of circumstellar disks is apparent in the data, accreting stars showing significantly lower average levels respect to non accreting ones.

Low mass NGC 2264 members also display saturated emission levels, $\text{Log}(L_X/L_{bol}) \sim -3$. Investigating the X-ray variability of the sources detected in our HRI data, I find that Classical T Tauri Stars are significantly more variable than Weak Lined T Tauri Stars.

I derive activity levels for members of the young ZAMS NGC 2516 cluster and compare them with those of Pleiades stars, of roughly the same age, but with different metallicity. I find that *G* and *K* stars appear to be subluminous in NGC 2516 respect to the Pleiades. This result hints toward a role of metallicity in the determination of coronal activity.

Finally, by complementing the original observations with published data on two star forming regions, ρ Ophiuchi, and Chamaeleon I, and on the Pleiades cluster, all partially re-analyzed here in a consistent way, I try to derive a coherent description of activity evolution from the early PMS to the ZAMS. $\text{Log}(L_X/L_{bol})$, for stars of a given mass, is observed to increase in the first $3 - 5$ Myrs and to reach the saturation level, -3 . This early evolution is slower for lower mass stars. Following this phase, low mass stars keep saturated activity levels up to the ZAMS, while more massive stars de-saturate at some point between the age of the Chamaeleon I region and that of the Pleiades. I find that the PMS data is compatible with the following picture: PMS stars have $\text{Log}(L_X/L_{bol}) \sim -3$, i.e. at the same level of small Rossby number MS stars, with the exception that accretion and/or the presence of disks acts to reduce their X-ray emission. Modern PMS evolutionary models and measured rotational periods indeed suggest that young stars *should*, have saturated emission according to the activity - Rossby number relation observed for main sequence stars. As the number of accreting/disked stars decreases with time, the fraction of saturated stars of a given mass increases and the mean activity level approaches the saturation level.

Full thesis available at: www.astropa.unipa.it/~ettoref

Near-infrared Study of Luminous Young Stellar Objects

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Ph.D degree awarded: March 2002

We have investigated circumstellar features of massive young stellar objects (YSOs) to understand their environment and to search for the relation to their evolutionary phases, by near-infrared spectroscopy and imaging. The observed objects are 45 *IRAS* sources from the list by Campbell, Persson, & Matthews (1989) (CPM objects). The luminosities (10^2 – $10^5 L_\odot$) and the spectral energy distributions (SEDs) similar to Class I sources indicate that the CPM objects are pre-cursors of Herbig Ae/Be (HAeBe) stars — intermediate-mass (~ 2 – $10 M_\odot$) pre-main-sequence stars. Thus, by comparing our observations with those of HAeBe stars in the literature, we investigated the circumstellar evolution of intermediate-mass YSOs from embedded sources (CPM objects) to visible sources (HAeBe stars).

The thesis is based on four observations: (1) low-resolution spectro-photometry in the *HKL* band, (2) *J*, *H*, and *K'* band imaging, (3) *K* band spectroscopy, and (4) *L* band spectroscopy and spectropolarimetry.

In the low-resolution spectrophotometry ($R \sim 40$), we use two dust features in the $3 \mu\text{m}$ band as indicators of the extent of the UV radiation fields around the YSOs: i.e., $3.1 \mu\text{m}$ H₂O ice absorption found in dense regions protected from UV radiation and $3.3 \mu\text{m}$ unidentified infrared band (UIB) emission found in regions exposed to UV radiation. The CPM objects are classified into four types — objects with the ice absorption (hereafter “A” objects); those with the UIB emission (“E” objects); those with both the ice absorption and the UIB emission (“A/E” objects); and those with neither of the two features (“N” objects). As a result of examining the relationship between the classification and the SEDs, we propose that the “A” objects evolve to “A/E”, “E”, “N” objects, and HAeBe stars, in that order, as the extinction due to the circumstellar matter decreases.

In the *J*-, *H*-, and *K'*-band imaging, approximately 90% of the CPM objects were seen to be surrounded by nebulosities with a typical size of ~ 0.2 pc. We found loose relationships between the near-infrared nebulae and the $3 \mu\text{m}$ dust features: (1) nebulae around the “A” objects can be explained by the scattered light of the central stars; (2) nebulae around the objects with UIB emission require another emission component in addition to the scattered light — most likely emission from very small grains (VSGs); (3) the “N” objects tend to have faint or no nebulosity, which is similar to HAeBe stars. The results indicate that the classification based on the $3 \mu\text{m}$ dust features represent the evolution of extended circumstellar material (such as dust envelope).

On the other hand, the *K*-band spectroscopy ($R \sim 500$) traces hot dust and gas regions close to the stars. We observed 33 CPM objects and detected Br γ emission, H₂ [1 – 0 S(1)] emission, and CO (2 – 0) emission in 97%, 34%, and 22% of them, respectively. Br γ emission and CO emission are generally thought to occur in stellar winds or inner circumstellar disks of YSOs. We found that the detection rate and the intensity of these lines do not depend on the SEDs nor the classification based on the dust features. Therefore we infer that the activity in the hot regions close to the stars ($\lesssim 1$ AU) change little from the embedded phase to the visible phase. On the other hand, H₂ emission was detected in objects with the reddest SEDs in our sample. To clarify if the H₂ emission is indicative of the youth of the associated YSOs, it will be necessary to examine whether it is due to the shock or fluorescence.

In the *L*-band spectroscopy ($R \sim 1400$), we examined H₂O ice absorption profiles of three CPM objects, whose absorptions at $\sim 3.4 \mu\text{m}$ are prominent compared with those of H₂O ice in cold molecular clouds. As a result, we conclude that the $3.4 \mu\text{m}$ absorption in one of the observed objects does not arise in the circumstellar region but in the foreground diffuse interstellar medium. Spectropolarimetry of the $3.4 \mu\text{m}$ absorption in this object shows no excess polarization accompanying the feature. Thus the $3.4 \mu\text{m}$ absorption carrier seems to reside in a population of small, non-polarizing carbonaceous grains in the DISM.

Thesis available at: <http://www.z.phys.nagoya-u.ac.jp/~ishii/thesis>

Physical Conditions and Structure of Molecular Gas in the Galactic Center

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Ph.D degree awarded: March 2002

The Galactic center (GC) region is under distinctive environment compared with that of the Galactic disk. In order to investigate star-forming activity in such a region, it is essential to study characteristics of molecular gas. We have studied global structure, kinematics, and distribution of physical conditions of molecular gas in the GC.

We have made survey observations of the GC in the CO $J = 2 - 1$ line using the Tokyo-Onsala-ESO-Calán 60 cm telescope at La Silla, Chile. Because the survey uses the same beam size ($9'$) and grid spacing ($0^\circ.125$) as the Columbia $^{12}\text{CO } J = 1 - 0$ survey [1], it is possible to compare these two datasets directly. The $^{12}\text{CO } J = 2 - 1$ spectra are obtained within the region $|\ell| \leq 6^\circ$, $|b| \leq 2^\circ$ (1800×600 pc at 8.5 kpc). The $^{13}\text{CO } J = 2 - 1$ spectra are taken toward 34 points at $b = 0^\circ$. The overall intensity ratio $^{12}\text{CO } J = 2 - 1 / ^{12}\text{CO } J = 1 - 0$ in the inner 900 pc ($|\ell| \leq 6^\circ$, $|b| \leq 1^\circ$) is measured to be 0.96 ± 0.01 : which is markedly higher than the typical value in the Galactic disk, $\simeq 0.6$, and is close to the average value in central regions of nearby spirals, 0.89 ± 0.06 [2]. The overall isotopic intensity ratio $^{13}\text{CO } J = 2 - 1 / ^{12}\text{CO } J = 2 - 1$ is 0.10 ± 0.01 . To investigate physical conditions of the gas, we compare the two intensity ratios with the results from one-zone large velocity gradient (LVG) calculations. The $^{12}\text{CO } J = 1 - 0$ line opacity is found to be $\lesssim 1$: this may result from high temperature and large velocity dispersion within the clouds. Longitude-velocity distributions of physical conditions are also derived. The gas thermal pressure, $p/k = n(\text{H}_2)T_k$, is found to be high within the central $\simeq 100$ pc. This region (“high pressure region”) coexists with ^{13}CO arms [3] and H II regions [4].

We have developed a method to derive positions of molecular clouds along the lines of sight. It is based on quantitative comparison between the CO emission line and the OH absorption line, and is independent of gas kinematics. It is applied to the GC using the data from the Columbia CO survey and OH survey made by Jodrell Bank 76 m telescope [5]. In the resultant face-on map, the majority of the CO emission comes from a central condensation with a size of 500×200 pc. Its major axis is tilted with respect to the line of sight by an angle of 70° with the positive longitude end being closer to us. Radial velocity field within it shows a clear sign of noncircular motion: the gas in the far side is receding whereas the gas in the near side is rather approaching. This noncircular velocity field may be induced by a barred potential. The so-called “Expanding Molecular Ring” (EMR) feature is also tilted so that the positive longitude end is closer to us. This geometry agrees with the interpretation that the EMR is a projection of an elongated orbit in the barred potential, rather than the original “expanding ring” picture. A face-on map of thermal pressure is derived in the same way as mentioned above. Within the central $\simeq 100$ pc, the pressure is found to be high ($\gtrsim 10^5 \text{ cm}^{-3} \text{ K}$). In this region (“high pressure region”), the gas is accumulating to form stars.

We have calculated gas motions in a fixed barred potential using the smoothed particle hydrodynamics method. The simulated distribution of the gas particles roughly consists of two components: (1) an oval (or a pair of arms) whose semimajor axis is $\simeq 3$ kpc, and (2) a gaseous bar inside the oval. While the oval is quasi-steady, features which appear inside the oval, such as clumps, streamers, and rings, are highly transient. The oval reproduces the well-known noncircular velocity of the so-called “3-kpc arm”; which agrees with previous works. Some observed features (the “135-km s $^{-1}$ arm”, Bania’s clumps, the EMR, etc.) are identified as gas streamers, clumps, and rings inside the oval.

Based on the three types of study described above, we propose an unified picture of molecular gas near the GC. The gas within the central $\simeq 3$ kpc, taking forms of clumps, streamers, and rings, gradually falls inward. At the innermost region with a radius of $\simeq 100$ pc, accumulated gas has been forming stars continuously or intermittently.

Gas and dust around young low-mass stars: from envelopes to disks

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Ph.D degree awarded: February 2002

The thesis is divided into two parts.

In part 1, the evolution of the gas in disks of various ages is studied through direct and indirect observations of the gas content using *ISO-SWS* data. We present the result of a survey of H_2 toward more than a dozen disks around T Tauri and Herbig Ae stars. The H_2 $S(0)$ and $S(1)$ lines are detected toward several pre-main sequence sources and indicate temperatures of ~ 100 K. The presence of warm gas is qualitatively consistent with flaring disk models where the surface layer is heated by radiation from the central star. The masses derived from the direct observation of H_2 are compared with indirect estimates of disk masses using CO and dust continuum emission. The masses inferred from CO are lower by factors of 10–200 due to CO photodissociation in the outer layers and freeze-out in the cold mid-plane. The warm gas mass traced by H_2 is typically a few % of the total gas + dust mass obtained from millimeter continuum data, assuming a standard gas/dust ratio of 100. We also report on the first attempt to determine directly the gas mass in young debris-disks. A substantial amount of H_2 , ranging from 0.1–6 M_{Jup} , is detected toward β Pictoris, HD 135344 and 49 Ceti, which is much larger than the inferred dust masses in particles smaller than a few millimeter in size. Thus, residual primordial gas can persist into the debris-disk phase, extending the timescale for giant planet formation.

The results of *ISO-SWS* H_2 observations of a set of diffuse, translucent and photon-dominated regions (PDRs) are given, for comparison with the disk observations. The intense mid-infrared H_2 emission from PDRs has been one of the surprising results from *ISO*, since the lines are stronger than predicted by pre-*ISO* models. The observations of the PDR IC 63 and of the peripheral regions of S140 molecular cloud confirm this trend and extend it to regions with lower density and exposed to lower ultraviolet intensity. They rule out explanations in terms of geometry and enhanced heating due to gas-grain drifts, but suggest that either the H_2 formation rate or the grain photoelectric heating efficiency needs to be changed. The non-detection of H_2 rotational lines toward diffuse and translucent clouds suggests that such clouds do not contribute significantly to the emission observed toward pre-main sequence stars.

Submillimeter observations of low- and high- J transitions of a selected number of molecules in the disks around two T Tauri and two Herbig Ae stars are presented. Only simple molecules are detected, and the data confirm the order of magnitude depletions seen around other T Tauri stars. The CN/HCN ratio is found to be particularly high, especially toward Herbig Ae stars, and is indicative of photodissociation processes in the upper layers of the disks. DCO^+ is detected for the first time in disks, and a high $\text{DCO}^+/\text{HCO}^+$ abundance ratio is found, suggesting that deuterium fractionation processes are effective in disks. The observed abundance ratios are compared with those found toward protostars and in solar-system objects.

In Part 2, the first results are presented from an infrared spectroscopic survey of a few intermediate mass young stellar objects in the Vela molecular cloud complex using the *Very Large Telescope* of the European Southern Observatory. Strong absorptions by H_2O and CO ice are found, with weaker absorptions due to other ices and gas-phase CO in some objects. In particular, solid methanol is detected toward an intermediate-mass protostar in Vela with abundances of ~ 3 –5%, compared to values up to 30% around massive protostars. The high quality of the data allows a detailed study of the ice band profiles through comparison with laboratory spectra, in particular with recent data on porous ices. The porosity of the water ice mantle is a factor that was not considered in previous studies of interstellar ices although it controls the trapping and diffusion of more volatile species like CO. The study presented in this thesis shows that porous water ice mantles with embedded CO molecules or clusters and inclusion of other minor species form a viable alternative model for the structure of interstellar icy mantles.

Budget of oxygen in the interstellar medium: the contribution of the ISO/LWS spectroscopic data

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Ph.D degree awarded: December 2001

Oxygen is the most abundant element after Hydrogen and Helium in the Universe. It is therefore of prime importance to know in which form Oxygen is found in the different phases of the interstellar medium (ISM). The constraints imposed by SWAS and ISO observations represent a challenge for theorists as they are in contradiction with the current models.

In which form is the Oxygen in molecular clouds and what are the main Oxygen bearing species ? The gas in cold molecular clouds is mainly cooled by atomic Oxygen through its lines in the infrared.

First, the tools used during my research are presented, notably the LWS instrument on board the Infrared Space Observatory (ISO). This instrument allowed the observation of the lines of the Oxygen in atomic form.

Observations towards star forming regions (HII regions) far from the sun are then presented. The far ultraviolet radiation field emitted by the massive stars illuminates and photo-dissociates the surrounding gas, creating a photo-dissociation region (PDR). The infrared atomic lines of Oxygen ([OI] 63 μm and [OI] 145 μm) and of ionized Carbon ([CII], 158 μm) dominate the gas cooling in these regions.

Absorption of the strong continuum emitted by bright sources in some of the observed lines of sight can trace the molecular and diffuse clouds which lie in the galactic spiral arms. The fit of the observed spectra towards two particular HII regions, W49N and Sagittarius B2, allow to characterize both the emitting PDR and the molecular clouds along the lines of sight.

This work shows that most of the Oxygen in the gas phase is in atomic form in the molecular clouds. This result is in contradiction with the theoretical works, but these observations agree with the SWAS ones showing that the abundance of the O₂ molecule is much less than predicted by the models. These results will help to better constrain the theoretical works to come.

http://www.cesr.fr/doctoran/france/docteurs/charlotte_vastel.htm#These

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Information from Dr T J Harries, School of Physics, University Of Exeter, EX4 4QJ, UK. email: th@astro.ex.ac.uk to whom applications (CV, statement of research interests & list of publications, plus the names and contact details of three referees) should be sent by 31st March 2002, quoting Ref No r4391. See www.astro.ex.ac.uk for information on the group's activities.

EQUAL OPPORTUNITIES EMPLOYER

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A St Andrews Fellowship in Astronomy is available from 1st September 2002. This fellowship is to encourage expertise in astronomy research and teaching and is funded for three years, with a possible extension for a further two years. The position includes a half-time teaching load, allowing for a generous allocation of research time. The candidate is therefore expected to undertake a world-class research program complementary to our current research areas. The research interests of the Astronomy group include the search for extra-solar planets, star and planet formation, magnetic activity of young stars, accretion in interacting binary stars, galactic dynamics and active galaxies.

You must have a PhD and ability to pursue independent research as evidenced by a record of publications.

Salary: 17,626 - 26,491 pounds per annum

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Application packs from Personnel Services, University of St Andrews, College Gate, North Street, St Andrews, Fife KY16 9AJ, (tel: 01334 462571, by fax 01334 462570 or by e-mail Jobline@st-andrews.ac.uk).

We regret applications cannot be made by e-mail.

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Postdoctoral position - University of Montreal - Star formation hydrodynamics

Applications are invited for a postdoctoral position in the Département de physique at the Université de Montréal to begin as soon as possible after May 2002. The ideal candidate is a Ph.D. candidate or recent Ph.D. and has experience in numerical hydrodynamics related to star formation problems. The appointment will initially be made for one year, with the possibility of renewal for up to a total of three years. The postdoctoral fellow will collaborate with Prof. Bastien and with Dr. Alan Boss (Carnegie Institution) on protostellar collapse calculations. Interested applicants should send their curriculum vitae, list of publications, and the names of three referees to:

Prof. Pierre Bastien,
Physics Department,
University of Montreal,
PO Box 6128, Downtown St.,
Montreal Quebec H3C 3J7 Canada.
E-mail contact: bastien@astro.umontreal.ca

Applications may be submitted by email (postscript or word files only), or by regular mail. The deadline for receipt of applications is April 15th, 2002.

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/> .

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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.

Meetings

First Announcement STAR FORMATION WORKSHOP 2002

Magnetohydrodynamics, Radiation Diagnostics, and Chemistry of Star Formation

June 12-17, 2002, Taroko Gorge, Taiwan

Web site: <http://sf2002.asiaa.sinica.edu.tw/>

Dear Colleagues,

The annual Summer Star Formation Workshop of the Center for Star Formation Studies (<http://www-space.arc.nasa.gov/csf/>) will be held in Taroko Gorge, Taiwan this year, hosted by the Institute of Astronomy and Astrophysics, Academia Sinica, Taiwan (ASIAA). The dates are set to be June 12-17.

The scientific programs will cover the following aspects:

MHD Processes in Star Formation: Star Forming Processes, MHD Simulations and Numerical Codes, and Turbulences; Radiation Diagnostics: Clouds and Cores, Low Mass Stars, High Mass Stars, and Very Low Mass Stars; Chemistry in Star Forming Regions and Processes, Chemistry in Circumstellar Disks; SMA, Sub-mm Sciences, and Interferometry.

There is a special focus on the sub-mm science and interferometry because the host (ASIAA) and SAO are partners on the SMA project.

This year, we will adopt a format similar to that of the Gordon Conferences. Each session chair will give a 15 min introduction or summary for the session. There will be approximately 5 speakers in each session thus far, and each will last for 20 min, followed by 10 min of question period. Traditionally, this is a workshop for people in the SF community to exchange latest ideas, therefore, the content of the talks will be more toward recent and new results than previously published work.

The Scientific Organizing Committee (SOC):

H. Shang (Chair, Organizer), K. Y. Lo (Co-Organizer)

D. Hollenbach, C. Lada, G. Laughlin, S. Lizano, A. Natta, N. Ohashi, E. van Dishoeck, D. Wilner

The Local Organizing Committee (LOC):

J. Lim (Chair) A. Allen, W.-P. Chen, M. Choi, N. Hirano, Y.-J. Kuan

sf2002_loc@asiaa.sinica.edu.tw.

LOCATION: The workshop will be held at the Grand Formosa Taroko in the Taroko National Park, located in the outer edge of the Central Mountains near the northeastern shore of Taiwan. It is also the east-most point of the first East-West freeway across the island, through the Central Mountains. The Taroko National Park is perhaps the most beautiful national park in Taiwan, with its steep marble gorges and towering mountains providing spectacular views (http://www.cpami.gov.tw/taroko/english/e_menu.htm). The Grand Formosa Taroko is a 5-star hotel located in the heart of the national park, providing convenient excess to many trails (<http://www.grandformosa-taroko.com.tw/>).

TRANSPORTATION: Overseas participants will normally arrive at the Chiang Kai-Shek (CKS) International airport (<http://www.eksairport.gov.tw/>), which is connected by a freeway to Taipei. The drive between CKS airport and downtown Taipei usually takes about 40 minutes.

We strongly urge all participants to arrive in Taipei by June 11. The ASIAA will provide round-trip train rides for all participants to the Grand Formosa Taroko on June 12, returning to Taipei in the afternoon of June 17. More details will be provided in the Second Announcement. For those arriving later and/or leaving earlier, you will have to pay all transportation costs between Taipei and the Grand Formosa Taroko. We will provide information on how to arrange transportation between these two locations in the Second Announcement.

ACCOMMODATION: For the first 100 registered invited participants, the ASIAA will provide lodging for single-rooms at the Activities Center of the Academia Sinica in Nankang, Taipei, on June 11, and room and board based on

double occupancy at the Grand Formosa Taroko on the nights of June 12-16. If a single room is preferred, please make your request on the registration page, and pay the extra cost directly to the hotel on checking out. Accommodations can be also arranged at one's own expense at the Howard International House in Taipei (across from the new building of ASIAA within the campus of NTU) on June 17.

For late participants, the ASIAA can arrange either single or double-room accommodations as requested on the registration page, but the participants will have to pay for the costs.

To secure proper demographic representation of the participants, the first 100 accommodation slots will be distributed as follows: US 50, Asia 25, and the rest of world 25, based on the major affiliation of the participants.

More information will be available about student participants in the second announcement.

ABSTRACTS: Please submit a title and an abstract for your proposed contribution to the workshop.

REGISTRATION: To register, please fill out the registration page accessible via the "Registration" link on the workshop home page (<http://www.asiaa.sinica.edu.tw/sf2002>). All costs are indicated on this page. We anticipate the workshop WEB site to be operating by 1 March 2002

The maximum limit of all participants is 120. The host can provide partial travel support (USD\$200) upon arrival for the first 60 registered participants from outside of Asia. For late registrants, you will be notified before the end of April if your registration has been accepted. All outside participants will be made on a first come, first serve basis. The deadline for registration is 31 March 2002.

The Chemistry of Star Formation - A Parallel Meeting at NAM 2002
Tuesday 9th and Wednesday 10th April 2002
University of Bristol, UK

The Astrophysical Chemistry Group of the Royal Society of Chemistry and the Royal Astronomical Society is arranging a two-day meeting on The Chemistry of Star Formation, in parallel with the UK National Astronomy Meeting, which is open to all.

The meeting will focus on the overlap and interplay between astronomical and chemical research, and how the two subjects are both vital to our understanding of star forming regions. Invited speakers include:

Prof. Eric Herbst (Ohio State University)
Dr. Martin Mccoustra (University of Nottingham)
Prof. Stephen Price (UCL)
Dr. Ian Sims (University of Birmingham)

Full details can be found on the web at
<http://www.strw.leidenuniv.nl/~fraser/NAM2002>

ABSTRACT SUBMISSION

Oral and poster contributions are very welcome from all observational astronomers, theoreticians, laboratory astrophysicists / astrochemists with an interest in this meeting. To submit an abstract please visit the web address above.

THE CLOSING DATE FOR ABSTRACT SUBMISSION / REGISTRATION / ACCOMODATION REQUESTS IS MARCH 5th 2002.

Applicants will be informed by March 10th if their abstract has been accepted for an oral or a poster contribution.

CONFERENCE ORGANISING COMMITTEE

If you have further questions regarding this parallel meeting please do not hesitate to contact one of the conference organisers with your questions:

Dr. H. J. Fraser - fraser@strw.leidenuniv.nl
Dr. J. Rawlings - jcr@star.ucl.ac.uk
Dr. D. Ward-Thompson - Derek.Ward-Thompson@astro.cf.ac.uk