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Abstracts of recently accepted papers

Physical properties of the OMC-2 and OMC-3 cores from CS and $C^{18}O$ observations

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We have investigated the properties of the OMC-2 and OMC-3 cores in the Orion giant molecular cloud using high spatial and spectral resolution observations of several transitions of the ^{13}CO, $C^{18}O$, $C^{32}S$ and $C^{34}S$ molecules taken with the SEST telescope. The OMC-2 core consists of one clump (22 $M_\odot$) with a radius of 0.11 pc surrounded by a cluster of 11 discrete infrared sources. The H_2 column density and volume density in the center of this clump are 2 10^{22} cm^{-2} and 9 10^5 cm^{-3} respectively. From a comparison between physical parameters derived from $C^{18}O$ and $C^{32}S$ observations we conclude that the molecular envelope around the core has been completely removed by these sources and that only the very dense gas is left. OMC-3 shows a more complex elongated structure in $C^{18}O$ and CS than OMC-2. The $C^{32}S$ and $C^{34}S$ maps show that the denser region can be separated into at least three sub-cores of roughly equal sizes (radius $\simeq$ 0.13 pc), with $n(H_2) = 6\ 10^5$ cm^{-3}, and a mass of 10 $M_\odot$ (from $C^{32}S$). The very different masses obtained for the central core from $C^{18}O$ and $C^{32}S$ (55 and 12 $M_\odot$ respectively) indicate that a massive envelope is still present around the very dense sub- cores. We report the first detection of several molecular outflows in OMC-3. The presence of an IRAS source and the first detection of these outflows confirm that star formation is going on in OMC-3. Based on the different physical properties of these regions compared with OMC-1, OMC-2 appears to be in an intermediate evolutionary stage between OMC-1 and OMC-3.

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The occurrence of H_2O masers in HII regions

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The results of a survey of 22.2 GHz H_2O maser emission towards a large sample of H II regions (427) detected in hydrogen recombination lines (Lockman 1994) are presented. The sample favours classical H II regions with large excitation parameter. We found 68 water maser sources, 17 of which are new detections. Adding the detections found in the literature, the total number of masers associated with the sample is 80. The overall maser percentage is low (19%), much less than what found in samples of ultracompact (UC) H II regions. The percentage changes if we divide our sample into two sub-classes: H II regions known to have ultracompact components (i.e. where a younger generation of star formation is also present) and the rest. In the first sub-class the maser percentage is 28%, in the second 15%.

The total number of masers in H II regions where no UC component has been (so far) reported is 43. This value is greater than that expected from the ratio between the lifetime of the H II region (10^6 yr) and that of the maser phase, even assuming a maser lifetime as long as 10^5 yr. This implies that maser excitation (and star formation) occurs several times in the lifetime of the same star forming complex.

¿From 410 positions observed, 230 can be associated with a high degree of confidence to an IRAS Point Source. We expect that most of the H II regions not associated with IRAS PS are diffuse regions in the last phases of their evolution. The percentage of water masers in this sub-class is very low: 8%.

The number of masers with no counterpart in the Lockman sample (and above δ = -30°) is very large: 334. This number most probably reflects the extreme high density conditions known to exist in the earliest phases of an H II region, which strongly reduce its radio continuum and line emission.

The analysis of a homogeneous sample of classical H II regions allows to confirm in a quantitative fashion the well known result that the maser phenomenon occurs during the earliest phase of the evolution of a massive star and that it fades away as the H II region evolves into the diffuse stage.

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Optical outflows in the vicinity of LkHα 198

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LkHα 198 and its nearby companion V376 Cas are both Herbig Ae/Be stars. Here we report the discovery of a jet from LkHα 198, and the presence of a nearby embedded infrared source (LkHα 198B) 5" northeast of this star. The embedded source appears to drive both the well–known optical outflow and possibly the molecular outflow in this region, both of which were previously associated with LkHα 198. A number of very faint HH knots are also found in the vicinity of V376 Cas although their connection with this star, if any, is unclear. The direction of the LkHα 198 jet and its low radial velocity, support the notion that LkHα 198 is surrounded by a disk, seen virtually edge on at a position angle of approximately 70°. The LkHα 198 and LkHα 198B outflows, as well as the bipolar nebula centered on V376 Cas, all appear to be roughly aligned. Their direction, however, is not the same as that of the surrounding magnetic field.

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The Complete *Einstein Observatory* X-Ray Survey of the Orion Nebula Region

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We have analyzed archival *Einstein* Observatory images of a roughly 4.5 square degree region centered on the Orion Nebula. In all, 245 distinct X-ray sources have been detected in 6 High Resolution Imager (HRI) and 17 Imaging Proportional Counter (IPC) observations. An optical database of over 2700 stars has been assembled to search for candidate counterparts to the X-ray sources. Roughly half the X-ray sources are identified with a single Orion Nebula cluster member. The 10 hot main-sequence O6-B5 stars detected in Orion have X-ray activity levels comparable to field O and B stars. X-ray emission was also detected in the direction of a half dozen main sequence late-B and early-A stars. Since the mechanisms producing X-rays in late-type coronae and early-type winds cannot operate in the late-B and early-A type atmospheres, we argue that the observed X-rays, with $L_{\rm X} \sim 3 \times 10^{30}$ ergs s^{-1}, are probably produced in the coronae of unseen late-type binary companions. Over 100 X-ray sources have been associated with late-type pre-main sequence cluster stars. The upper envelope of X-ray activity rises sharply from mid-F to late-G, with $L_{\rm X}/L_{\rm bol}$ in the range 10^{-4} to 2×10^{-3} for stars later than $\sim$ G7. We have looked for variability of the late-type cluster members on time scales of a day to a year and find that $\frac{1}{4}$ of the stars show significantly variable X-ray emission. A handful of these stars have published rotational periods and spectroscopic rotational velocities; however, we see no correlation between X-ray activity and rotation. Thus, for this sample of pre-main sequence stars, the large dispersion in X-ray activity does not appear to be caused by the dispersion in rotation, in contrast with results obtained for low-mass main-sequence stars in the Pleiades and pre-main sequence stars in Taurus-Auriga.

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The Molecular Core and the Powering Source of the Bipolar Molecular Outflow in NGC 2264G

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We present NH_3(1,1) and (2,2), and radio continuum observations toward the bipolar molecular outflow NGC 2264G. We detected a high-density NH_3 core of 0.08×0.06 pc in size, $M \simeq 6 \left[X_{\rm NH_3}/10^{-8}\right]^{-1}\ M_\odot$, and $T_K \simeq 15$ K, located almost midway between the blueshifted and redshifted CO lobes of the outflow. None of the infrared sources detected so far (with the exception of IRAS 06384+0958) nor VLA 1, the radio continuum source previously detected in the area (and suggested as the powering source of the outflow), appears to be associated with the high-density molecular clump. However, we detected a new radio continuum source, VLA 2, close to the maximum of NH_3 emission. This continuum source shows a jet-like morphology, elongated in the direction of the bipolar molecular outflow. We propose that VLA 2 is a deeply embedded low mass star, and the most likely powering source of the bipolar outflow in NGC 2264G. We find that the mechanical luminosity of the wind from VLA 2 is of the same order as the mechanical luminosity of the outflow, and as the estimated stellar luminosity of the source. Thus, this remarkable source appears to provide a very efficient outflow acceleration mechanism.

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183 GHz water emission in W49N

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The $3_{13} - 2_{20}$ line of water at 183 GHz has been observed from the ground at three different periods toward W49N, a key galactic source in the study of water masers. The line profiles consist of two strong velocity spikes superimposed on a broad plateau extending over a velocity range of about 400 km/s. The first spike corresponds to the "ambient" cloud component (AC) which is observed in many other molecular lines, whereas the second spike (termed HVC, for high-velocity component) is blueshifted by about 36 km/s with respect to the ambient emission, and does not have known counterparts in other tracers. Although probably of maser nature, the 183 GHz water line emission is spatially extended along the cloud, and it is more stable in time than the 22 and 325 GHz lines of water. We give plausible lower limits of the water column density and abundance.

Furthermore, we report the discovery of a unusually fast CO outflow –with velocities in excess of 150 km/s – toward the center of W49N. A comparison of the H_2O and CO data suggests that the HVC feature arises in a dense layer of hot material which has been shock-compressed by the action of the outflows.

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Molecular gas in cometary globules: CG4 and CG6 in the Gum Nebula

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With the SEST telescope, we observed ^{12}CO(1-0), ^{13}CO(1-0), and C^{18}O(1-0) emission from the cometary globules

CG4 and CG6 in the Gum Nebula and also CS(2-1) and HCO^+(1-0) in CG4. There are $\approx 50\,M_\odot$ and $\approx 5.5\,M_\odot$ of molecular hydrogen, respectively, in CG4 and CG6. The gas kinetic temperature is $\approx 16\,K$ in both globules. The gas kinematics indicate the globules are strongly affected by ionization fronts on their surfaces. Red and blue line wings are found throughout CG4 and the velocity gradients suggest a divergent flow that may be responsible for the apparent disruption of the globule's head. In CG6, a head to tail velocity gradient indicates a dynamical age of 10^6 yr. We discuss a possible evolution scenario for these globules.

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The molecular content of the Rosette's teardrops

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We report the detection of the J=1→0 and J=2→1 lines of ^{12}CO and ^{13}CO, and of the J=2→1 and J=3→2 lines of CS, in the direction of the small tear drops of the Rosette Nebula. These objects appear in the optical as dark patches of $3-30''$ diameter against the bright HII region of the Rosette Nebula. The CO lines were detected in all the observed globules. One of the observed tear drops is still connected to a large elephant trunk by a tenuous filament, which has also been detected in ^{12}CO. The sizes of the ^{12}CO J=2→1 emitting regions are found to be similar to the optical sizes. The kinetic temperature of the globules is 15–20 K, and the beam–averaged molecular hydrogen densities inferred from the ^{13}CO lines range from 2 10^3 to 7 10^3 cm^{-3}. CS J=2→1 emission was detected toward two small tear drops and marginally toward another one. The CS J=3→2 line was detected in one of the above globules. Analisis of these lines yields to an upper limit of the density of $1-3$ 10^4 cm^{-3} for this tear drop. The masses range from ~ 0.02 $M_\odot$ for a well isolated and defined tear drop to ~ 0.5 $M_\odot$ for one which is still connected to a larger globule. Visual extinctions are also very low with typical values of $\sim 1-3$ mag.

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Cold dust around southern Herbig Ae/Be stars

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The results of a 1.3 millimetre continuum pilot search for cold dust around southern Herbig Ae/Be stars are presented. Significant millimetre flux was detected from 17 of the 33 target objects.

The data show no significant correlation between the infrared spectral index and the circumstellar dust mass. However, the Lada class II objects have in the average lower masses compared with the class I objects pointing to an evolutionary effect. Analysing the relation between fluxes scaled to a fixed distance and luminosities, we find a linear dependence in agreement with a relation found for less luminous young stellar objects.

We use a radiative transfer code for spherically symmetric envelopes with different dust components to model the spectra of selected objects and to deduce the dust mass. The spherical model fails to account for the high millimetre flux in the flat spectrum of the class II object HD 163296 even if amorphous carbon and fractal dust particles are considered. In this case, we applied a thin disk model which results in a flat energy distribution and can explain the 1.3 mm flux.

In addition, we discuss the R Coronae Australis region in more detail. We show that the strongest millimetre source in this area is not R CrA or T CrA but the deeply embedded infrared source IRS 7 which shares a number of properties with the well-known source L 1551-IRS5.

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Is HL Tau an FU Orionis System in Quiescence?

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A recent Nobeyama map of HL Tau reveals that gas is infalling in a flattened region $\sim 1,400$ A.U. around the central star. The apparent motion of the gas provides the necessary condition for the formation of a Keplerian disk with a radius comparable to the size of the primordial solar nebula. The inferred mass infall rate onto the disk is $\simeq 5 \times 10^{-6} M_\odot y^{-1}$ which greatly exceeds the maximum estimate of the accretion rate onto the central star ($\sim 7 \times 10^{-7} M_\odot y^{-1}$). Consequently, mass must currently be accumulating in the disk. The estimated age and disk mass of HL Tau suggest that the accumulated matter has been flushed repeatedly on a time scale $< 10^4 y$. Based on the similarities between their evolution patterns, we propose that HL Tau is an FU Orionis system in quiescence. In addition to HL Tau, 14 out of 86 pre-main-sequence stars in the Taurus-Auriga dark clouds have infrared luminosities much greater than their otherwise normal extinction-corrected stellar luminosities. These sources also tend to have flat spectra which may be due to the reprocessing of radiation by dusty, flattened, collapsing envelopes with infall rates a few $\times 10^{-6} M_\odot$. Such rates are much larger than estimated central object accretion rates for these systems which suggests that mass must also be accumulating in these disks. If these sources are FU Orionis stars in quiescence, similar to HL Tau, their age and relative abundance imply that the FU Orionis phase occurs over a time scale of $\sim 10^5$ y and the quiescent phase between each outburst lasts $\sim 10^3 - 10^4$ y. These inferred properties are compatible with the scenario that FU Orionis outbursts are regulated by a thermal instability in the inner region of the disk.

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A Search for T Tauri Stars in High-Latitude Molecular Clouds. II. The IRAS Faint Source Catalog

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We present a catalog of infrared point sources from the IRAS Faint Source Survey at Galactic latitudes $|b| \geq 30°$. The aim of this paper is to provide a list of possible star-forming sites at high Galactic latitudes in order to address the question of whether or not the translucent molecular clouds (which are most easily identified at high latitudes) are capable of star formation. The primary list of sources has 12, 25, 60, and 100 μm fluxes within the range typical of pre-main sequence or T Tauri stars. A secondary list has the same range of 12, 25, and 60 μm fluxes, but only upper limits at 100 μm. A total of 131 candidates from the first category and 69 candidates from the second category are identified and their positions and infrared spectral characteristics tabulated. Although the colors and fluxes of these sources are typical of T Tauri or pre-main sequence stars and YSOs, extragalactic sources and planetary nebulae sometimes have similar colors. These lists provide a starting point for optical spectroscopy or other techniques to positively identify these objects.

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High resolution near-infrared imaging of the Trapezium: a stellar census

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We present high spatial resolution (0.35 and 0.65 arcsec FWHM) near-infrared images of the central 0.2×0.2 pc of the

Trapezium Cluster in the Orion Nebula, centred on the Trapezium OB stars. These images provide the most complete census of stars in this region, and we give accurate positions and near-infrared (2.1 μm) magnitudes for 123 stars. After accounting for line-of-sight projection, we estimate a stellar density for the cluster of $\sim 4.7\times10^4$ stars per cubic parsec in the ~ 0.1 pc diameter core. We identify stellar counterparts to virtually all the known dense knots of ionized gas seen at optical and radio wavelengths, strongly supporting the hypothesis that many are either intrinsic stellar radio emitters or circumstellar disks around stars, and not simply dense clumps of gas and dust. We derive approximate masses for the stars associated with the compact knots, finding that the majority are relatively low mass.

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The Circumstellar Environment of IRAS 05338-0624

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Millimeter continuum and spectral line observations with 10″, 30″, and 60″ resolution are used to characterize the structure and chemistry of the gas around the young, embedded star, IRAS 05338-0624. On arcminute scales, emission from dense gas tracers outline an isolated condensation centered on the IRAS source position. The condensation is characterized by a size of ∼60″, a density of 2×10^5 cm^{-3}, and a virial mass of 40 $M_\odot$. Interferometric CS J=2-1 observations show two peaks, one toward the continuum peak and the other toward a position 14″ west and 8″ south. Single dish maps of SO, CH_3OH, and SiO show pronounced wing emission to the west of the IRAS source, which interferometer observations reveal to be a compact region of outflow activity. CS emission at redshifted and blue shifted velocities reveals a bipolar outflow oriented with a position angle of 45° , while SiO emission appears to be tracing a fast shock interaction region at the CS red-lobe peak, 14″ west and 8″ south of the IRAS source. Finally, $H^{13}CO^+$ emission traces clumps of quiescent gas toward the IRAS source and adjacent to the blue lobe of the outflow.

Column densities and molecular fractional abundances are derived to explore the interaction between the surrounding condensation and the young stellar object. We find evidence for gas phase depletions within the overall condensation in several gas tracers (CO, CS, HCN, SO) but not in the region immediately around the young stellar object. Enhanced abundances of SO, CH_3OH and SiO (by factors of 4, >100, >1000, respectively) are observed in the shocked gas; these enhancements may be explained in terms of a non-dissociative shock liberating mantle materials which contain some amount of refractory materials, a moderate velocity dissociative shock in which only minor sputtering of Si occurs, or a shock which impacts surrounding material with a range of speeds.

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NGC2024 - IRS2: An Outburst in its Near Infrared Line and Continuum Emission

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We present new near infrared spectroscopy, photometry, and narrow band imaging of the young stellar object NGC 2024 IRS2. The data include high and low resolution spectra of Brγ, Brα, and Pfγ, single channel, JHKL′ photometry, and images in Brγ and nearby continuum. The source has had a burst in its infrared emission, typically increasing by one magnitude in continuum brightness and by factors of 4-8 in line intensity, since 1989, and apparently reached a maximum in 1991. A large velocity shift has occurred in the peaks of the hydrogen lines, from ≈ +40 km s^{-1} LSR in 1984 to ≈ -25 km s^{-1} at present. Observation of such dramatic changes is unprecedented in studies of luminous

YSO's. The data exclude external phenomena such as variable extinction or binary occultation as the origin of the observed variability, and appear more indicative of changes in the physical conditions of the star and its circumstellar environment.

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Post-Refurbishment Mission Hubble Space Telescope Images of the Core of the Orion Nebula: Proplyds, Herbig-Haro Objects, and Measurements of a Circumstellar Disk

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We report on observations of M42 made with the Hubble Space Telescope immediately after the successful repair and refurbishment mission. Images were made in the strongest optical emission lines of HI, [NII], and [OIII] and in a bandpass close to V. In a previous paper, the term proplyd was introduced to describe young stars surrounded by circumstellar material rendered visible by being in an HII region. We confirm the proplyd nature of 17 of 18 objects found earlier with the HST, incorporate 13 previously known VLA Sources into the class on the basis of their emission line appearance, and find 26 additional members not seen previously in other wavelengths. Half of the 110 stars brighter than V=21 show proplyd structure, which implies that more than half of the stars have circumstellar material since nebular structures are more difficult to detect than stars. The highly variable forms of the proplyds can be explained on the basis of a balance of ambient stellar gas pressure ! and radial pressure arising from t he stellar wind and radiation pressure of the dominant stars in the region. Arguments are presented explaining the proplyds as disks or flattened envelopes surrounding young stars, hence they are possible planetary disks. The characteristic mass of ionized material is 2 $\times 10^{28}$ gm, which becomes a lower limit to the total mass of the proplyds. A new, coordinate based, designation scheme for compact sources and stars in the vicinity of M42 is proposed and applied. Evidence is presented that one of the previously known bright Herbig-Haro objects(HH203) may be the result of a stream of material coming from a proplyd shocking against the neutral lid that covers M42.

One object, 183-405, is a proplyd seen only in silhouette against the bright nebular background. It is elliptical, with dimensions $0.9''$ by $1.2''$ and surrounds a pre-main-sequence star of at least $0.2 M_\odot$. The outer parts of this stellar disk are optically thin and allow column mass densities to be determined. We set a lower limit to this disk to be $0.1 - 4.4 \times 10^{28}$ gm, dependent on the assumed gas to dust mass ratio.

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Discovery of an Extremely High Excitation Herbig-Haro Object in Southeastern Vela

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A very high excitation Herbig-Haro (HH) object, designated as HH 171, has been discovered in a small dark cloud in southeastern Vela. Narrow band CCD imaging of the region and low dispersion spectroscopy for the objects as well as for some nearby objects have been obtained. Although the spectrum is somewhat peculiar as an HH object, several lines of evidence, in particular, the coexistence of reflection nebulosities and the presence of nearby reflection nabulae, indicate that the object is neither a planetary nebula nor a supernova remnant but an HH object. It has the highest [OIII]4959+5007/Hβ ratio among known HH objects. The relative weakness of the [SII] lines and the bipolar morphology is also discussed.

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Optical outflows in the vicinity of the southern Herbig Ae/Be Star vdBH 65b

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Although there are a large number of Herbig-Haro (HH) outflows now known from low mass pre-main sequence stars, i.e. classical T Tauri stars and embedded infrared sources of similar luminosity, this is not the case with their higher mass counterparts, the Herbig Ae/Be (HAeBe) stars. We report here the discovery of an outflow (HH140) from the HAeBe star vdBH 65b using the ESO Multi-Mode Instrument (EMMI) on the New Technology Telescope (NTT). A coronagraphic spot was employed to investigate the area close to this star. At least 3 additional outflows (HH141, HH142 and HH143) were found in its vicinity. A similar search around two other HAeBe stars (HD101412 and HD150193) showed no signs of optical outflows, nor for that matter any reflection nebulae, the presence of which is strictly required if a star is to be classified as a HAeBe star.

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Additional Constraints on Circumstellar Disks in the Trapezium Cluster

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We discuss new constraints on the population of compact ionized sources in the Trapezium Cluster thought to arise from the ionization by the central OB stars of circumstellar disks around low-mass pre-main sequence stars. We present new HST Planetary Camera observations of two of these candidate disk sources, resolving extended nebulosity around them. One source shows a small-scale ($\gtrsim$100 AU) bow-shock structure, previously seen on larger scales by O'Dell *et al.* We show that the circumstellar disk model is the most likely one for the majority of sources, although it remains plausible that some of the larger objects could be equilibrium globules. We combine the most complete censuses of compact radio sources and stars in the core region to derive the fraction of the stellar population that may be associated with a circumstellar disk. Our estimate of 25–75% is comparable to that found for PMS stars in the Taurus-Auriga dark clouds, indicating that the dense cluster environment of the Trapezium has not drastically reduced the frequency of disks seen around pre-main sequence stars.

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Water Masers Associated With Low Mass Stars: A 13 Month Monitoring Survey

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We report the results of a 13 month survey of embedded YSOs for H_2O masers using the Haystack 37 m telescope. YSOs were selected to be in an early phase of evolution based on IRAS colors and association with molecular outflows or dense cores. The sample was restricted to YSOs in nearby clouds (d$<$ 450 pc) with luminosities $<$ 120 $L_\odot$. Six new sources of water maser emission have been found, raising the total number of maser sources in this luminosity range

to 20. Three sources (L1448C, L1534B, and VLA1623) have luminosities less than 3 $L_\odot$. Of the YSOs monitored on a regular basis, we estimate that maser activity occupies at least one-third of the duration of the embedded state. All sources with $L > 25$ $L_\odot$ displayed some maser activity. Although the maser strength of a given source can vary by two orders of magnitude, there is a general correlation between maser strength and YSO luminosity. For YSOs with $L< 25$ $L_\odot$, no single property, such as the CO mass loss rate or luminosity at λ=6 cm, successfully predicts maser activity. We propose that other factors, such as the inclination of the outflow axis, may be important in enhancing the detectability of the masers in lower luminosity sources.

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