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Abstracts of recently accepted papers

On the relative importance of photoevaporative and hydrodynamic effects in the ablation of self-gravitating globules in compact H II regions

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We investigate in detail the process of hydrodynamic ablation, both for the case of subsonic and for supersonic flows, of isothermal self-gravitating globules. The results are then compared with those for photoevaporative mass loss to estimate which of the two processes is the dominant mechanism for the mass loss of self-gravitating globules embedded in compact H II regions. This material then goes on to mass-load the stellar wind, thereby altering its dynamical properties. Using our results we perform numerical simulations of the evolution of such H II regions, taking into account both of the possible mass loading processes, together with the effect of the finite lifetime of the globules. We find that for compact H II regions with central stars possessing high ionizing photon rates the photoevaporation process dominates.

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A Near-Infrared Imaging Survey of the ρ Ophiuchi Cloud Core

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We present results of the largest three-color near-infrared (NIR) imaging survey of the ρ Ophiuchi star-forming cloud core to date. The survey covers a square degree, which corresponds to a projected area of $\sim$ 2.2 pc $\times$ 2.2 pc at the distance of the Ophiuchus clouds (125 $\pm$ 25 pc). Mapping was carried out at J (1.25 μm), H (1.63 μm), and K (2.22 μm), to 90%, 10 σ completeness limits of J=15.0, H=14.5, and K=14.0. We catalog 4495 sources of which 2070 have K$\leq$14.0 and 2425 more either have 5σ or better detections at K (for 14.0$\leq$K$\leq$14.5) or have 4σ or better detections in at least two of the three survey bands (for K$\geq$14.5). We present accurate astrometry and photometry for all identified sources. We also tabulate cross-identifications for 449 previously observed NIR sources. Using the cross-identifications, we derive linear transformations between the differing photometric systems and use rather strict criteria to identify NIR variables.

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A Semi-Analytic Model for Supercritical Core Collapse: Self-Similar Evolution and the Approach to Protostar Formation

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We use a semi-analytic model to examine the collapse of supercritical cores (i.e., cores with a mass-to-flux ratio exceeding a critical value). Recent numerical simulations of the formation and contraction of supercritical cores show that the inner solution tends toward self-similar evolution. We use this feature to develop analytic expressions for quantities such as the density, angular velocity, and magnetic field. All forces involved in the problem (gravitational, magnetic, thermal, and centrifugal) can be calculated analytically in the thin-disk geometry of the problem. The role of each force during the contraction is analyzed. We identify the key role of ambipolar diffusion in producing a departure from an exact similarity solution. The slow leakage of magnetic flux during the supercritical phase is enough to significantly accelerate an otherwise near-quasistatic contraction. This leads to dynamic collapse with supersonic infall speeds in the innermost region of the core by the time of protostar formation. We find a time-dependent semi-analytic solution for the late supercritical phase, and asymptotic forms are obtained for important profiles at the moment that a central protostar is formed. We obtain estimates for the rotational velocity, infall velocity, and mass accretion rate at this moment. The mass accretion rate is significantly greater than the canonical C^3/G (where C is the isothermal sound speed and G is the universal gravitational constant) at the moment of protostar formation, although we argue that it is time-dependent and will eventually decrease. Comparisons are made with the predictions of existing spherical similarity solutions.

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Forbidden lines in Herbig Ae/Be stars. The [O I] (1F) 6300.31 Å and 6363.79 Å lines. II. Longslit observations of selected objects.

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This paper presents first long-slit spectroscopic observations of the forbidden [O I](1F) emission line regions around selected pre-main sequence Herbig Ae/Be stars. Contrary to the lower-mass T Tauri stars, the observations show that the selected Herbig stars do not reveal neither signs of extended or positionally decentered [O I](1F) emission regions, nor signs of outflows or jets in the proximity of the stars emitting that forbidden line.

A high-velocity component in the emission profile has only been confirmed in the spectrum of the peculiar FU Ori star Z CMa, in form of a profile showing an extended blue wing; this star is likely to have a disk or a companion star.

In the case of the prototype Herbig Ae star AB Aur the derived geometrical constraints on the size of the forbidden emission line region tend to rule out the presence of a significant circumstellar accretion disk.

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Polarization models of filamentary molecular clouds

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We study numerically the linear polarization and extinction of light from background stars in three types of models of elongated molecular clouds by following the development of the Stokes parameters. The clouds are assumed to be of cylindrical shape and penetrated by a helical magnetic field $\vec{B}$. In the first two models we study only the relative magnitude of the polarization assuming that the polarization is proportional to B^{μ}, where primarily $\mu = 2$. Provided there is no background/foreground polarization present we find from the cylindrically symmetric Model I that the angle of polarization has a bimodal character with the polarization being either parallel with or perpendicular to the axis of the filament. For some magnetic-field geometries both angles may exist in one and the same filament. It is concluded that it is not a straightforward task to find the magnetic-field-line pattern from the polarization pattern. If a background/foreground polarization exists or, as in Model II, the filament is not cylindrically symmetric, the bimodal character of the angle of polarization is lost. By means of Model III we have, using semi-empirical methods based on the Davis–Greenstein mechanism, estimated the absolute degree of polarization in the filamentary molecular cloud L204. It is found that the polarization produced by the model is much less than the polarization observed. We therefore conclude that most of the polarization measured in the L204 cloud is not produced in the cloud itself but is constituted by a large-scale background/foreground polarization.

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Sulphuretted Molecules in Hot Cores

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The chemistry of sulphur-bearing molecules resulting from grain-mantle evaporation into warm gas is described. Evaporation of ices in which all the available sulphur is contained in H_2S drives a hot phase chemistry which produces SO, SO_2, CS, OCS, and H_2CS. It is predicted that S_2 can attain significant abundances in hot cores. Large variations in abundances occur as a core evolves and eventually almost all the original H_2S is converted to SO and SO_2. The SO/H_2S and SO/SO_2 abundance ratios could be useful as a crude molecular clock to measure the time since mantles were disrupted.

Model calculations can reasonably explain the observed distribution of S-bearing molecules in the Orion Hot Core, the Orion Compact Ridge and in Sgr B2(N). In these sources, the theory requires that OCS be formed on grain surfaces. Hot core chemistry alone cannot explain the sulphur chemistry in the Sgr B2(M) source.

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Deuterated Methanol in the Orion Compact Ridge

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We have investigated the chemistry of hot cores containing methanol, formaldehyde and their deuterated forms. We have computed the deuterium fractionation ratios attainable by addition of H and D atoms to CO on cold grain surfaces. We can easily reproduce the observed $HDCO/H_2CO$ and D_2CO/H_2CO ratios, but find that, as there is an additional path to CH_2DOH, the CH_2DOH/CH_3OD ratio is typically 3. This result is in conflict with the conclusion of Jacq et al. that the observed gas phase CH_2DOH/CH_3OD ratio of $\approx 1.1-1.5$ in the Orion Compact Ridge source is consistent with their production in grain mantles. We show that, when these mantles are evaporated, the CH_2DOH/CH_3OD ratio can be altered by gas phase reactions which preferentially form CH_3OD via reaction of H_2DO^+ with CH_3OH . We find that an unrealistically high HDO/H_2O ratio of ≈ 0.1 is necessary to drive the CH_2DOH/CH_3OD ratio within the observed range. Before concluding that the observed gas phase CH_2DOH/CH_3OD ratio is inconsistent with these grain surface reactions, we recommend that more accurate determinations of this ratio be made in the Compact Ridge and in other hot cores.

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Thermal and dynamical balance in dense molecular cloud cores

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We consider the thermal and dynamical balance in dense, molecular cloud cores. We point out that because such cores are heated throughout their volumes by cosmic rays, but cool radiatively by means of optically thick lines, they are likely to be dynamically unstable and at best in only a form of quasi-static equilibrium. We also draw attention to the possibility that if such cores undergo an external impulse which is large enough to produce a velocity difference $\Delta v \leq c_s$, where c_s is the thermal sound speed, then the cooling rate rises suddenly and pressure support drops, which leads to gravitational collapse and fragmentation.

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Near-IR imaging of the molecular outflows in HH 24-26, L 1634 (HH 240-241), L 1660 (HH 72) and RNO 15 FIR

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Narrow-band images in H_2 v=1-0 S(1) (2.122 μm) and adjacent continuum (2.104 μm) are presented of a number of outflows that are driven by young, deeply embedded sources. We report the detection of a H_2 outflow associated with the Class 0 source in the HH 24-26 region, HH 24-MMS, as well as extensive H_2 line emission in the HH 25 and HH 26 CO outflows. In L 1634 a sequence of well-defined molecular bow shocks in the blue-shifted outflow lobe points to variability in the flow velocity, while in L 1660, the poorly aligned H_2 knots suggest a wide outflow opening angle and perhaps also a variable flow direction. We also report the discovery of a highly collimated molecular jet associated with the embedded source RNO 15 FIR.

These observations provide evidence that molecular outflows from young stars are driven by collimated jets. Indeed, in H_2, we likely observe the molecular shocks which sweep up ambient gas to form the associated CO outflows. We find, however, no obvious correlation between the presumed age of the source of each outflow (based on its IR excess), and the length or luminosity of the flow in H_2.

A preprint (with figures), is available from http://www.cp.dias.ie/∼cdavis/

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New Protostellar Collapse Candidates: An HCO^+ Survey of the Class 0 Sources

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We have observed 23 Class 0 sources in the HCO+ J=4-3 and 3-2 lines. The mean bolometric temperature of the 16 sources with well-determined values is 44 K and the mean luminosity is 5.7 $L_\odot$, excluding two sources of considerably higher luminosity. Nine sources, including three sources previously suggested to be collapsing, have the correct (blue) spectral line asymmetry for infall in both lines. Three sources have the opposite (red) asymmetry in both lines, and one source, L1157, has a red asymmetry in HCO+ J=4-3 and a blue asymmetry in J=3-2. The rest have no significant or consistent asymmetry. The H13CO+ J=4-3 and 3-2 lines were also observed to find the velocity of the ambient gas, and sources with an interesting line asymmetry were mapped. A Monte Carlo code was used to produce an evolutionary sequence of collapsing cloud models of the HCO+ J=4-3 and 3-2 lines and to compare various diagnostics of the resulting line profiles. The same code was used to compare infall models to the observations in one source,

L1527. The results were consistent with previous collapse models. Based on integrated intensity maps of the line peaks and wings, as well as the velocity of the H13CO+ line, we select six of the nine sources with a blue line asymmetry as good candidates for protostellar collapse. Further evidence is needed to establish that infall is taking place. The HCO+ spectra are not conclusive because bipolar outflows produce strong emission, which can confuse the issue in any individual source. However, the predominance of blue asymmetries over red asymmetries is not naturally explained in outflow models, whereas it is expected in collapse models.

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Structure and kinematics of a protostar: mm-interferometry of L 1157

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We present high angular resolution (2.5″) interferometric images of ^{13}CO J $= 1 \rightarrow 0$, C^{18}O J $= 1 \rightarrow 0$, and λ 2.7 mm continuum emission around L1157-mm, a suspected protostar powering an energetic molecular outflow. The continuum emission consists in two distinct components. The Class 0 object L1157-mm is seen as a compact source of size $\leq 1''$ (440 AU) and mass $\simeq 0.2\,M_{\odot}$, which is marginally resolved and elongated perpendicular to the outflow axis. In addition, spatially-extended low-level emission is observed and likely arises at the heated edges of the cavity excavated by the outflow in the surrounding envelope. Simple modelisation shows that such an interacting structure can explain the observed morphology and the spectral energy distribution of the source.

The line observations indicate that ^{13}CO mostly originates from the envelope and the limb-brightened edges of the outflow, whereas the C^{18}O emission is more directly associated with the compact continuum source. Weak evidence for rotation has been found. Comparison of the two line tracers shows proeminent redshifted self-absorption in the ^{13}CO spectrum which is very suggestive of infall motions. The infalling medium seems to be confined in a large (a few thousands AU) flattened structure.

These observations provide a quite detailed description of the structure of a Class 0 protostar, which appears to have a complex vicinity where the outflowing and accreting phenomena are closely linked together.

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A Multiresolution Infrared Imaging Study of LkHα 198

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New near-infrared images of the young, nebulous intermediate-mass (Herbig Ae/Be) star LkHα 198 using direct imaging, adaptive-optics compensated speckle imaging (AOCSI), and standard speckle imaging reveal complex structure in its circumstellar dust distribution. At high resolution, LkHα 198 is found to possess a barlike feature which extends $\sim 3''$ from the star in either direction. Geometrical considerations suggest that the bar is unlikely to represent light scattered by either a standard circumstellar disk or a disequilibrium "pseudodisk", or by an ambient halo illuminated by starlight escaping along the polar axis of a disk. Its orientation suggests that it may be associated with the fan-shaped nebula which surrounds LkHα 198. The infrared companion 6″ north of the star is found to be significantly extended at near-infrared wavelengths, and may be an example of a deeply embedded object whose envelope is at least partially illuminated from the outside.

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A Postscript preprint of this paper is available at http://gulliver.gps.caltech.edu

A 1.3 mm dust continuum survey of Hα selected T Tauri stars in Lupus

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We have observed a sample of 32 Hα selected T Tauri stars in the Lupus 2 and 3 T association with the facility bolometer at the SEST and detected cold dust emission at 1.3 mm from 12 of the objects. For the remaining objects we have derived 3σ upper limits (≈ 40 mJy), which suggest that the cold dust masses are less than $5 \cdot 10^{-5}\,M_\odot$. For stellar masses below $0.7\,M_\odot$ the mean disk mass (gas + dust) is approximately 3 % of the stellar mass.

The face value detection rate (38 %) of the Lupus stars is very similar to that of young stars in the Taurus-Auriga association. Thus, the young stellar population in Lupus seems to have an equal incidence of circumstellar disks. In comparison to Taurus-Auriga the low-mass pre-main sequence stars in Lupus show a lack of disk masses below $3 \cdot 10^{-3}\,M_\odot$ (gas + dust), which in part can be explained by the absence of weak-line T Tauri stars in our sample.

Both samples show a strong correlation between relative disk mass and stellar age. Considering the absolute disk mass of 1.3 mm detected sources in Lupus we see a tentative decrease with increasing age, too, while there is no correlation for the Taurus-Auriga sample. This effect might be due to different modes of star formation: isolated star formation in Taurus-Auriga versus clustered star formation in Lupus. Considering both samples globally none of the 6 stars older than 3 Myr shows dust emission, which could mean that almost no small dust grains are left over in the disk at this age. Furthermore, for both samples we do not see any indication that more massive stars have more massive disks. On the contrary, statistical tests suggest that the absolute disk mass as well as the relative disk mass decreases with increasing stellar mass.

Finally, in order to investigate the age-dependent behaviour of the spectral energy distribution, we have determined the IR indices α_{IR} between $\lambda = 2.2\,\mu$m and $\lambda = 12 \ldots 25\,\mu$m (IRAS) for 11 sources of our sample. According to the revised IR classification by André & Montmerle (1994) these objects belong to the IR class II. Neither a correlation between the infrared indices and the stellar age nor between the infrared indices and the disk mass could have been found.

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On The Circumstellar Matter Distribution Around Herbig Ae/Be Stars

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The spectral energy distributions (SEDs) observed in Herbig Ae/Be stars are critically analyzed in connection with a spherically symmetric model for matter distribution around the central objects. The possibility that the dusty component is described by a MRN-DL (Mathis, Rumpl, & Nordsiek 1977, Draine & Lee 1984) mixture and is constituted by particles with mean sizes greater than those typical of the interstellar medium is considered.

We find that while spherical models with interstellar-like dust are able to describe the observed SEDs in the visible, IR, and radio region, they generally fail to fit the sub-mm fluxes. A better agreement is obtained if the absorption coefficient of the dust at FIR wavelengths follows a dependence which is shallower than that of the standard MRN-DL mixture. In this case general agreement amongst the observed and the model derived spectral type, distance and visual extinction is found. Inconsistencies in sub-mm fluxes obtained by different authors are discussed in connection with the different telescopes used and the confusion of the sources. An indication is given for the density distribution around Herbig Ae/Be which, if modeled with a power law, goes as the inverse of the radial distance in most cases.

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Is SVS 13 the Exciting Source of the HH 7-11 Flow?

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Since 1976 it has been believed that the Herbig-Haro (HH) objects 7-11 are excited by SVS 13, an infrared source located approximately along the line defined by this chain of nebulosities. It is well established that the exciting sources of HH flows are frequently detected in the centimeter continuum. When observed with high angular resolution, these radio sources appear as subarcsecond thermal jets that are elongated in the direction of the outflow axis. We present sensitive, high angular resolution VLA observations of the region that show radio continuum emission associated with SVS 13 but also reveal at about $6''$ to its SW the presence of a second radio source previously undetected at other wavelengths. This source is better aligned with the axis defined by the HH 7-11 outflow and also exhibits an elongation along this axis. We favor this new object as the most likely exciting source of this classic HH system. However, high-angular resolution molecular observations of the region are required to test this proposition.

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A dust model for the frosty nebula HH 100 IRS

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Comprehensive model calculations are presented in order to interpret the observed spectral energy distribution of HH 100 IRS as a function of dust parameters such as the grain size, the ice volume fraction, and the fluffiness of the particles. The radiative transfer calculations treat the spectroscopic signatures of various ice bands in detail. The observed infrared spectrum together with the strength of the water ice band of HH 100 IRS is successfully reproduced if an upper size limit of the grains below 1 μm is used. Large, comet-like grains, with sizes above 1μm, result in a poor fit to the observations of HH 100 IRS. Contributions from scattering by the grains to the long wavelength wing of the 3.08 μm H_2O absorption are thus excluded. Our best fit dust model includes grains with sizes $a \leq 1\mu$m, a vacuum volume fraction of $f_{vac} = 0.5$, and a mass ratio of ice–to–refractive materials of $M_{ice}/M_{ref} = 0.5$. The modeled dust cloud towards HH 100 IRS is characterized by a dust density distribution of $\rho(r) \propto r^{-1}$, a total gas mass of 0.3 $M_\odot$, an inner ice evaporation zone with extension of $r \leq 23$ AU, and an outer boundary of 2300 AU.

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The stability of accreting triples

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We address the question of the stability of newly formed stellar triple systems that are undergoing accretion. Accretion of infalling gas can help stabilise unstable triple systems and can destabilise stable ones. The dynamics of the accretion depend critically on the specific angular momentum of the infalling gas relative to that of the triple system and on the component masses. Low relative specific angular momentum accretion helps stabilise systems where a lower mass single star is orbiting a more massive binary, by preferentially shrinking the binary's separation over that of the binary-single. High relative specific angular momentum accretion also helps to stabilise these systems, but by increasing the binary-single separation. Moderate values of the relative specific angular momentum of the infalling matter can destabilise previously stable systems. Systems with comparable mass single components are stabilised by accreting matter with significant angular momentum while they can be destabilised by accreting zero angular momentum material. Triples comprised of a binary orbiting a more massive star are easily destabilised for most values of the specific angular momentum of the infalling gas. Such systems are unlikely to survive significant accretion. We comment on how these scenarios can arise depending on the triple formation mechanism and discuss the implications that accretion has for stellar multiplicity.

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IRAS sources associated with small nebulae in star forming regions: Optical and near infrared images

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Optical CCD and near-IR broad and narrow-band imaging have been obtained of a sample of 11 small optical nebula associated with IRAS sources in star forming regions in order to perform a morphological and photometric study. More than 130 sources were detected in K. The $J-H$ versus $H-K$ diagram was used to establish their nature. The most massive regions, Gy 2-18, Gy 4-2 and Gy 3-7, have embedded clusters of early-type stars and their associated nebulae were found to be photoionized. The IRAS sources in L1455, L1473, L1165 and Gy 4-1 with near-IR reflection nebulae were found to be Class I young stellar objects with associated molecular outflows. The results for each region is discussed in detail.

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Intense molecular emission from the Lagoon Nebula, M8

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The discovery is reported of the second strongest source of mm and submm wavelength CO line emission, towards M8, the Lagoon Nebula in Sagittarius. The $\sim 31\,M_\odot$ molecular core has dimensions $\sim 0.2\times0.3$ pc and is centred on the O7V star Herschel 36 (H 36), near the Hourglass Nebula in the core of M8. Emission from the CO line wings extends to the north and south of the Hourglass, although a lack of near-IR H_2 emission indicates that outflow activity is much less prominent than in many active star-formation regions, and suggests that the CO line wings may trace the expanding edge of a cavity around H 36. The molecular line data are compared with new near-IR narrow-band, continuum-subtracted images in He I, H_2, and H^+ (Brγ) lines and archival HST emission-line images in Hα, [O III], and [S II]. The optical and near-IR data are found to be broadly consistent with previous photo-ionisation models of the Hourglass, which is excited by H 36. However, there are substantial variations in the He I/Brγ line ratio which are difficult to explain.

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Preprints available at http://www-star.qmw.ac.uk/m8

Dissertation Abstracts

A Multi-Wavelength Study of 12 Dark Globules

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We have studied the internal structures of the 12 dark globules by using the observations in the radio, infrared, and optical wavelengths. For the radio we have utilized the 13.7 m dish of TRAO and 4 m dish of Nagoya University. For the infrared we used the IRAS data basis. In the optical we performed star-count analysis with the POSS data base.

Full mapping observations were made in the ^{13}CO(J=1→0) transition, while in the ^{12}CO(J=1→0) cross scan observations were only made. From the column density maps, we identified 18 sub-condensations out of the 12 dark globules. Assuming spherical symmetry for each sub-condensation, we derived various physical properties for all the 18 sub-condensations.

As regard to the internal density distribution, the dark globules closely resemble the tidally truncated iso-turbulent clouds. As regard to the dynamical nature, most of the globules are under an iso-turbulent condition and are approximately in the hydrostatic equilibrium. Some of the globules seem to undergo a systematic motion of expansion or contraction. The scaling relations between the line width and radius and between the line width and mass were found to hold true for the small dark globules, too. But the exponents are somewhat larger than the ones for the cores of GMC's. The indices of the scaling relations suggest that the globules are in the hydrostatic equilibrium only in an approximate sense.

The stability of the dark globules has been analyzed by using the scalar virial theorem. When the globules are approximated by a uniform sphere of equivalent mass, one third of the equivalent spheres are likely to collapse, one sixth of them are expected to expand, and the rest are in an oscillatory equilibrium. The globules in the diffuse phase of the oscillatory equilibrium may not be detected by conventional means, because they are too rarefied to get CO molecules excited or to shield molecules from UV photons, or because they may not withstand the tidal disruption by neighboring clouds.

We let the optical extinction and the IR dust optical depth trace out the dust component of the dark globules. To match the resolutions of the IRAS images at 60 and 100 μm, only the 100 μm flux map was de-convoluted by using the maximum correlation algorithm. The code for MCM has been developed specifically for this purpose. The 60 and 100 μm maps were further corrected for the background flux, and we extract from the observed flux the component emanating from the globule only. Using these maps we calculated the dust optical depth at 100 μm. The distribution of the optical extinction was derived from the star count on the POSS plate. The counting was done with a reseau of size $2' \times 2'$.

The distribution of dust constituent within the dark globules correlate well with that of gas in an overall sense. The 100 μm dust optical depth traces the dust column density better than the 100 μm sky flux does. The relations between $\tau_{\rm d}(100\mu{\rm m})$ and $N(^{13}{\rm CO})$, and between $N(^{13}{\rm CO})$ and $A_{\rm V}$ are both fitted better by a polynomial of order 2 rather than by a linear function; thereby, ratio of the CO column density to the dust shows a decreasing tendency with increasing $\tau_{\rm d}(100\mu{\rm m})$. This strongly indicates that the CO molecules condense onto the dust particles in the dense central part of the dark globules.

From this study, we found that the dark globule can be characterized as a tidally truncated iso-turbulent cloud in an approximate hydrostatic equilibrium. Some of them are likely to undergo a gravitational collapse.

Shocked Molecular Hydrogen in the Orion "Bullets"

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The physics of shocked outflows in molecular clouds is one of the fundamental astrophysical processes by which the cycle of star formation in our Galaxy is regulated. I outline the basis of our understanding of the star formation process and the viol ent outflow always associated with it, the physics of shocks in molecular gas, and the consequent excitation of molecular hydrogen (H_2). It is demonstrated that molecular hydrogen is the best observational diagnostic of this hot, shocked molecular gas and an introduction is given to the observational techniques of near-infrared spectroscopy required in its measurement. I describe a detailed observational study of the physics of shocked H_2 excitation and dynamics in the nearby massive star forming re gion of the Orion giant molecular cloud, the brightest source of its type, using the recently upgraded CGS4 near-IR spectrometer at UKIRT.

We have demonstrated that integrated [FeII] 1.644μm line profiles in the Orion "bullets" are consistent with theoretical bow-shock predictions for two different "bullets". We have identified a uniform, broad background component pervading the region in both Fe^+ and H_2 which is inconsistent with a fluorescent componen t due to the ionizing radiation of the Trapezium stars alone. A collisionally broadened background component of unidentified origin is measured to be Gaussian in profile with an average FWHM of 26$\pm$2.5kms^{-1} in the H_2 1-0 S(1) line after deconvo lution of the instrumental profile and a peak velocity of 2.5$\pm$0.5kms^{-1}, close to the local ambient rest velocity. Crucially, the extended H_2 "bullet" wakes have allowed us to dissect individual molecular bow shock structures but the broad (i ntrinsic FWHM$\leq$27kms^{-1}), singly-peaked H_2 1-0 S(1) profiles observed in the two most clearly resolved, plane-of-sky oriented wakes challenge our present understanding. It is very difficult to reconcile *any* steady-state molecular bow shoc k model with these observations in Orion. To fit a single C shock absorber model to individual H_2 profiles implies a magnetic field strength far in excess of observed estimates and is not consistent with the bow-shaped wake morphology.

Alternatively, we may still not be resolving multiple H_2 shock fronts along the line-of-sight. For example, multiple overlapping bullet wakes could give rise to merged sets of doubly-peaked profiles resulting in approximately Gaussian shaped profiles. However, given the appearance of single bow shaped wakes at many observed positions, the accuracy of single Gaussian line-fits, the velocity resolution of our observations (FWHM=23.1$\pm$0.3kms^{-1}) and that we see this phenomenon in *two* differe nt wakes, this explanation is expected to be excluded.

If we cannot fit the profiles in Orion with steady state molecular shocks it may be necessary to model the effects of instabilities and turbulence. This will have important consequences. Not only will line profiles be broadened but level populations of shocked species will be altered and hence the observed column densities over a range of transitions.

Observations of a range of H_2 column densities in the K band have confirmed the existence of a near-constant background excitation mechanism pervading the entire Orion "bullets" region. The background H_2 emission can be modelled by a combination o f fluorescent and shock excited mechanisms, in agreement with the broad H_2 line profiles observed. It is thermalized in the v=1 levels but higher levels are dominated by fluorescence. Measurement of the H_2 excitation in the "bullet" wakes M42 HH 126-053 and M42 HH120-114 shows a near constant emission spectrum, within each wake, that may be modelled by a combination of shocked and fluorescent excitation, now more strongly dominated by collisional processes but also containing an intrinsic wake-on ly fluorescent component. The column density ratios clearly show a range of gas temperatures as expected for cooling, post-shock gas. Furthermore, the uniformity of these ratios on small-scales (these observations) and also on large scales, contradicts co mbinations of fundamentally different types of shock. However, the near constancy of this excitation with position *within* each individual wake is inconsistent with bow C shock models previously fitted at OMC-1, in which significantly different line ratios occur depending on the shock velocity which varies in the bow.

New Books

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Edited by R.H. Hewins, R.H. Jones & E.R.D. Scott

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