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Abstracts of recently accepted papers

Clouds as turbulent density fluctuations. Implications for pressure confinement and spectral line data interpretation

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We examine the idea that diffuse HI and giant molecular clouds and their substructure form as density fluctuations induced by large scale interstellar turbulence. We do this by closely investigating the topology of the velocity, density and magnetic fields within and at the boundaries of the clouds emerging in high-resolution two-dimensional simulations of the ISM including self-gravity, magnetic fields, parameterized heating and cooling and a simple model for star formation. We find that the velocity field is continuous across cloud boundaries for a hierarchy of clouds of progressively smaller sizes. Cloud boundaries defined by a density-threshold criterion are found to be quite arbitrary, with no correspondence to any actual physical boundary, such as a density discontinuity. Abrupt velocity jumps are coincident with the density maxima, indicating that the clouds are formed by colliding gas streams. This conclusion is also supported by the fact that the volume and surface kinetic terms in the Eulerian Virial Theorem for a cloud ensemble are comparable in general, and by the topology of the magnetic field, which exhibits bends and reversals where the gas streams collide. However, no unique trend of alignment between density and magnetic features is observed. Both sub- and super-Alfvénic motions are observed within the clouds.

In the light of these results, we argue that thermal pressure equilibrium is irrelevant for cloud confinement in a turbulent medium, since inertial motions can still distort or disrupt a cloud, unless it is strongly gravitationally bound. Turbulent pressure confinement appears self-defeating, because turbulence contains large-scale motions which necessarily distort Lagrangian cloud boundaries, or equivalently cause flux through Eulerian boundaries.

We then discuss the compatibility of the present scenario with observational data. We find that density-weighted velocity histograms are consistent with observational line profiles of comparable spatial and velocity resolution, exhibiting similar FWHMs and similar multi-component structure. An analysis of the regions contributing to each velocity interval indicates that the histogram “features” do not come from isolated “clumps”, but rather from extended regions throughout a cloud, which often have very different total velocity vectors.

Finally, we argue that the scenario presented here may be also applicable to small scales with larger densities (molecular clouds and their substructure, up to at least $n \sim 10^3\text{--}10^5 \text{ cm}^{-3}$), and conjecture that quasi-hydrostatic configurations cannot be produced from turbulent fluctuations unless the thermodynamic behavior of the flow becomes nearly adiabatic. We demonstrate, using appropriate cooling rates, that this will not occur except for very small compressions ($< 10^{-2} \text{ pc}$) or until protostellar densities are reached for collapse.

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Formation of Interstellar Ices Behind Shock Waves

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We have used a coupled dynamical and chemical model to examine the chemical changes induced by the passage of an interstellar shock in well shielded regions. Using this model we demonstrate that the formation of H₂O in a shock will be followed in the post-shock phase by depletion of the water molecules onto the grain surfaces. To attempt to discriminate between the creation of ices behind shocks and their production by means of grain surface chemistry, we examine the deuterium chemistry of water before, during, and after a shock. We show that chemical evolution in the post-shock gas can account for both the deuterium fractionation and the abundance of CO₂ relative to H₂O observed in interstellar and cometary ices. Given the pervasiveness of shocks and turbulent motions within molecular clouds, the model presented here offers an alternate theory to grain surface chemistry for the creation of ices in the interstellar medium, ices that may ultimately be incorporated into comets.

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The Detection of Magnetic Fields Toward M17 through the HI Zeeman Effect

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We have carried out VLA Zeeman observations of HI absorption lines toward the HII region in the M17 giant molecular cloud complex. The resulting maps have $60'' \times 43''$ spatial resolution and 0.64 km s^{-1} velocity separation. The HI absorption lines toward M17 show between 5 and 8 distinct velocity components which vary spatially in a complex manner across the source. We explore possible physical connections between these components and the M17 region based on calculations of HI column densities, line of sight magnetic field strengths, as well as comparisons with a wide array of previous optical, infrared, and radio observations.

In particular, an HI component at the same velocity as the southwestern molecular cloud (M17 SW) $\sim 20 \text{ km s}^{-1}$ seems to originate from the edge-on interface between the HII region and M17 SW, in un-shocked PDR gas. We have detected a steep enhancement in the 20 km s^{-1} HI column density and line of sight magnetic field strengths (B_{los}) toward this boundary. A lower limit for the peak 20 km s^{-1} HI column density is $N_{HI}/T_s \geq 5.6 \times 10^{19} \text{ cm}^{-2}/\text{K}$ while the peak B_{los} is $\sim -450 \mu\text{G}$. In addition, blended components at velocities of $11-17 \text{ km s}^{-1}$ appear to originate from shocked gas in the PDR between the HII region and an extension of M17 SW, which partially obscures the southern bar of the HII region. The peak N_{HI}/T_s and B_{los} for this component are $\geq 4.4 \times 10^{19} \text{ cm}^{-2}/\text{K}$ and $\sim +550 \mu\text{G}$, respectively. Comparison of the peak magnetic fields detected toward M17 with virial equilibrium calculations suggest that $\approx 1/2$ of M17 SW's total support comes from its static magnetic energy, while the other half of its support is supplied by the turbulent kinetic energy (including MHD waves).

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http://www.pa.uky.edu/brogan/brog_publ.html

Circumstellar Kinematics and the Measurement of Stellar Mass for the Protostars TMC1 and TMC1A

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We present observations of two protostars in the Taurus Molecular Cloud, TMC1 and TMC1A, obtained using the Owens Valley mm array. ¹³CO and C¹⁸O J=1-0 data, and observations at 2.7mm in the continuum, reveal the

presence of molecular gas in circumstellar envelopes out to a radius of 1000 AU. The velocity field in these envelopes is well described by Keplerian rotation and shows no signature of infall motions. The dynamical masses of the central objects, derived from the velocity structure of the isotopic CO emission, are 0.2–0.4 M_{\odot} for TMC1, and 0.35–0.7 M_{\odot} for TMC1A depending upon the assumed inclination, with typical uncertainties in the mass measurements at a given inclination of 10%. Our determinations of the stellar masses enable us to place upper limits on the accretion rates in these sources of $\dot{M} \leq 4 \times 10^{-7} M_{\odot} \text{ yr}^{-1}$, which is at least an order of magnitude lower than that needed to assemble the observed mass with a constant \dot{M} assuming a typical age of 10^5 yr. We conclude that the accretion rate is not constant in time.

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<http://www.mrao.cam.ac.uk/~dbrown/info/publications.html>

Binary fraction in low-mass star forming regions: a reexamination of the possible excesses and implications

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Various surveys of low-mass binaries in star forming regions have been performed in recent years. They reached opposite conclusions concerning possible binary excesses in some of these associations. I develop a consistent method to reanalyze all these studies, so that I can compare all data consistently, and understand the previous findings. I also report the detection of five new companions to Taurus members.

It appears that binary fraction in Taurus exceeds the main sequence value by a factor of 1.7 in the range 4–2000 AU. The companion star fraction in this separation range is the same as the *overall* main sequence fraction. Ophiuchus, Chameleon, and possibly Lupus show similar excesses, although with lower confidence levels. Binaries in Ophiuchus seem to have larger flux ratios (towards faint companions) than in Taurus.

It appears very unlikely that all very young star forming regions have binary excesses. The binary fraction seems to be established after ≈ 1 Myr, but the precise nature of the difference between various regions is still unclear (overall binary fraction, orbital period distribution). It is not currently possible to put constraints on the binary formation models: higher angular resolution and larger sample sizes will be required.

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A VLA search for embedded young stellar objects and protostellar candidates in L1630

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Five molecular cloud cores in L 1630 have been observed with the VLA in the C configuration at a wavelength of 3.5 cm. These cores were identified in molecular line emission by a previous study and contain numerous clumps which are excellent candidates for sites of low-mass star formation. To a 5σ limit of 0.1 mJy, corresponding to an 8.4-GHz luminosity of $1.9 \times 10^{16} \text{ erg s}^{-1} \text{ Hz}^{-1}$ (uncorrected for primary beam attenuation), most (>75%) of the clumps within these cores do *not* have an associated radio continuum source.

Of the three likely associations, two were discovered in previous surveys of LBS 23 (HH 24–26), one of which (SSV61) shows evidence for radio variability, while the third source is spatially coincident with one of the clumps in LBS 18 and may be a new class 0 protostar candidate. Another new discovery is that HH 26IR is probably detected at the 4σ level. Radio emission has also been detected from two of the early-type stars exciting the NGC 2068 reflection nebula (HD 38563 C and S).

These results are in agreement with earlier work which proposes that in (the northern part of) L 1630, a large fraction of the molecular gas is not directly involved with star formation at the current epoch, although there is evidence that low-mass star formation is in the early stages at a number of locations.

A tentative suggestion is that perhaps only young stellar objects in the earliest and latest phases of protostellar evolution exhibit detectable radio continuum emission. The earliest emission may be due to bremsstrahlung from an ionized jet, which declines due to a decreasing accretion rate or outflow efficiency. The later emission is due to gyrosynchrotron processes arising as a consequence of a magnetic field in the vicinity of the star-disc interface. Alternatively, a combination of the source geometry and optical depth may be responsible for such an apparent correlation. Further observations of a larger sample are required to test whether this correlation is seen in a wider view of low-mass star formation.

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Copies may be obtained from <http://ast.leeds.ac.uk/~agg/research/pubs.html>

Disk and Outflow in Cepheus A-HW2: Interferometric SiO and HCO⁺ Observations

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This paper reports observations of the HCO⁺(1 → 0) and SiO(2 → 1) lines, and of continuum emission at $\lambda = 3.4$ mm, toward the Cepheus A East star-forming region. The HCO⁺ line shows emission up to velocities of ~ 50 km s⁻¹ relative to the ambient cloud velocity. The spatial distribution of the high-velocity gas is bipolar, centered on HW2, and extends for $\sim 1'$ along PA = 55° – 60°. The orientation of this molecular outflow is very similar to that of the radio jet and CO emission associated with HW2. This confirms that current mass-loss from HW2 takes place in the NE-SW direction. The momentum rate of the HCO⁺ outflow is $1.3 \times 10^{-2} M_{\odot} \text{ km s}^{-1} \text{ yr}^{-1}$, twenty times larger than that of the ionized jet from HW2, suggesting that the jet could be largely neutral. Peaks of HCO⁺ emission coincide with some of the radio continuum sources in the region, consistent with outflow-ambient gas interaction. Multiple episodes of outflow activity from either one precessing source, or a number of powering sources would explain the detection of moderate-velocity HCO⁺ emission toward the HW7 chain of sources. The continuum emission at 3.4 mm is strongly peaked toward HW2, confirming that this is the most likely powering source for the outflow.

The SiO emission is barely elongated along PA = -33°, i.e., almost perpendicular to the HCO⁺ outflow. A velocity trend consistent with a gradient of ~ 31 km s⁻¹ over 2'' is detected along the major axis of the SiO structure; these motions could be bound by 200 M_⊙. Published H₂O and CS observations support our suggestion that this represents the outer, ~ 750 AU radius, part of a circumstellar disk, although further observations are needed to confirm this interpretation.

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Measurements of magnetic field strength on T Tauri stars

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We have investigated the magnetic field strength of one weak-line and four classical T Tauri stars. The magnetic field strength is derived from the differential change of the equivalent width of photospheric *Fe I* lines in the presence of a magnetic field, calculated using a full radiative transfer code. The method was successfully tested by applying it to a non-magnetic solar-type star, and to VY Ari which is believed to have a strong magnetic field. For two of the classical T Tauri stars, we find a product of magnetic field strength and filling factor $B \cdot f = (2.35 \pm 0.15)$ kG for T Tau, and $B \cdot f = (1.1 \pm 0.2)$ kG for LkCa 15. For the classical T Tauri star UX Tau A and the weak-line T Tauri star LkCa 16 the detection is only marginal, indicating magnetic field strengths of the order of 1 kG and possibly of more than 2 kG, respectively. No field could be detected for the classical T Tauri star GW Ori. For the two classical T Tauri stars for which we have detected a field, we find the filling factors to be larger than ~ 0.5 , which indicates that the magnetic field covers most of the photosphere. We also show that ignoring a magnetic field can, depending on the lines used, result in errors in effective temperature and underestimates of veiling.

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Spectropolarimetry of Magnetospheric Accretion on the Classical T Tauri Star BP Tauri

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High resolution ($R \approx 60,000$) circular spectropolarimetry of the classical T Tauri star BP Tau is presented. No net polarization is detected in photospheric absorption lines, placing strong limits (3σ) on the mean longitudinal magnetic field (± 200 G) present over the surface of the star. On the other hand, strong circular polarization is measured in the He 5876 Å *emission* line of BP Tau, indicating a mean longitudinal magnetic field of $+2460 \pm 120$ G in the line formation region. This implies accretion occurs preferentially along large scale magnetic loops which occupy a small fraction of the stellar surface. These observations represent the first direct evidence for magnetically controlled accretion onto classical T Tauri stars.

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<http://plasma2.ssl.berkeley.edu/cmj/html/preprints>

JCMT/SCUBA Sub-Millimeter Wavelength Imaging of the Integral Shaped Filament in Orion

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We present the first high dynamic range and sensitivity images of the sub-millimeter wavelength continuum emission at $450\mu\text{m}$ and $850\mu\text{m}$ of the “Integral Shaped Filament” in the northern portion of the Orion A cloud which contains the nearest site of on-going high-mass star formation. The images trace the morphology and spectral index of optically thin emission from interstellar dust and constrain the grain temperature and emissivity. The images reveal a remarkable chain of compact sources embedded in a narrow ($< 1' = 0.14$ pc) high column density filament that extends over the $50'$ (7 pc) length of the map with faint extended structure surrounding it. While many compact sources contain extremely young protostars, others may be pre-collapse phase cloud cores. The brightest region, associated with OMC1, contains a remarkable group of dust filaments radiating radially away from this high luminosity core that

coincide with filaments of NH_3 emission. The spectral index is uniform between $450\mu\text{m}$ and $850\mu\text{m}$ except for the ridge sources, the photo-heated HII region edges including the Orion Bar, and the location of molecular hydrogen shocks.

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Depletion of CO in a cold dense cloud core of IC 5146

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We have used the IRAM 30m telescope to map the C^{18}O ($1\rightarrow 0$) and ($2\rightarrow 1$) transitions in a region of $0.5 \times 0.5 \text{ pc}^2$ ($200'' \times 200''$) in the nearby (460 pc distance) molecular cloud IC 5146 at resolutions of down to 0.025 pc. Additionally, we have observed the corresponding C^{17}O transitions towards 24 positions in the central region of the cloud as a check on optical depth effects. On the basis of these observations, we conclude that the C^{18}O emission observed by us is optically thin and that the observed C^{18}O ($2\rightarrow 1$)/($1\rightarrow 0$) ratio is consistent with gas at 10 K and density in the range 10^4 to 10^5 cm^{-3} . We have estimated C^{18}O column densities over the region mapped, using an LVG program to correct for excitation effects, and have compared them, at the same spatial resolution of $30''$, with the dust extinction derived from the NIR images of Lada et al. (1998). From this, we find a roughly constant, though with considerable dispersion, ratio of C^{18}O column density to visual extinction (A_V) in directions with A_V less than ~ 10 magnitudes. The ratio is compatible with previous determinations of the $[\text{C}^{18}\text{O}]/[\text{H}_2]$ abundance ratio, e.g. $1.7 \cdot 10^{-7}$ as obtained by Frerking et al. (1982). At extinctions higher than ~ 10 magnitudes, however, there is a systematic fall-off in the ratio $N(\text{C}^{18}\text{O})/A_V$ which we attribute to depletion of C^{18}O onto dust ice mantles within the dense, $n \geq 10^4 \text{ cm}^{-3}$, and cold, $T_{\text{dust}} \leq 15 \text{ K}$, $T_{\text{gas}} \sim 10 \text{ K}$, core interior. This fall-off is also seen, though with less statistical significance, in our observed dependence of $N(\text{C}^{17}\text{O})/A_V$ with A_V . We thus think it unlikely that optical depth effects are influencing our conclusions. We have additionally made pointed C^{18}O ($1\rightarrow 0$) and ($2\rightarrow 1$) observations towards 94 background stars with extinction greater than 10 magnitudes from the study of Lada et al. (1994). These in general confirm our mapping results.

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Preprint available at <http://www.ph1.uni-koeln.de/~kramer/publications.html>

An investigation of the B335 region through Far Infrared Spectroscopy with ISO

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We present far infrared spectra of the B335 dark cloud region, obtained with the Long Wavelength Spectrometer (LWS) on-board the ISO satellite. Deep spectra were obtained towards the far infrared outflow exciting source, located in the B335 core, and on the three associated Herbig Haro (HH) objects HH119 A, B and C. In addition, a region of about 9' in R.A. and 4' in Dec. was mapped which covers the whole molecular outflow.

[CII]158 μm emission was found to be uniformly distributed across the observed region, with the intensity expected for a photodissociation region excited by the average interstellar field. The [OI]63 μm emission was detected only towards two out of the three HH objects and from the B335 FIR source; excitation from the high-velocity shocks responsible for the HH119 knots can account for the observed line intensity. CO line emission from the rotational levels $J=15$ to $J=18$ was detected only towards B335 FIR and can be modelled as arising in warm gas whose excitation temperature is in the range 150-800 K, located in a compact ($\sim 10^{-3}$ pc) and dense ($n_{H_2} \sim 10^6 \text{ cm}^{-3}$) region. If we assume that the CO $J = 6 \rightarrow 5$ line observed from the ground is also emitted from the same gas component, we derive for this component a temperature of 350 K and a density of $5 \cdot 10^5 \text{ cm}^{-3}$. Current collapse models for the B335 core fail to predict the presence of such warm gas in the infalling source envelope, at the spatial scales implied by our model fit. It is likely that the molecular emission is excited in a low-velocity ($v \sim 10 \text{ km s}^{-1}$) non-dissociative shock, originating at the base of the flow.

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On the nature of cyclic variability of the UX Ori type stars. II. UX Ori, SV Cep and RZ Psc.

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From the analysis of long-term photometric observations of three UXOR's – UX Ori itself, SV Cep, and RZ Psc we found that periodic components are probably present in their variability. For SV Cep multiperiodic behavior is suspected, with nonlinear interaction (modulation) of different periods. The probable reason of cyclic variability is the large-scale inhomogeneity of circumstellar dusty disks. We propose the interaction of the disk with binary stellar system, or planetary system, as a cause of such inhomogeneity.

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The location of UX Ori-type stars in the Hertzsprung-Russell diagram

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The fundamental parameters (stellar luminosity, mass, radius, age) of a sample of 11 stars with non-periodic Algol-type brightness minima were determined on the basis of the long-term photometric monitoring. All stars investigated by us are located above a zero-age main sequence in the Hertzsprung - Russell diagram in agreement with the suggestion about their youth. It is shown that the UX Ori-type stars do not differ from other Herbig Ae/Be stars by their fundamental parameters.

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A Physical Limit to the Magnetic Fields of T Tauri Stars

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Recent estimates of magnetic field strengths in T Tauri stars yield values $B = 1\text{--}4 \text{ kG}$. In this paper, I present an upper limit to the photospheric values of B by computing the equipartition values for different surface gravities and

effective temperatures. The values of B derived from the observations exceed this limit, and I examine the possible causes for this discrepancy.

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Adaptive Optics Imaging of the Orion Trapezium Cluster

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We have imaged an area ~ 5 arc min² at the center of the Trapezium Cluster in Orion in the K-band using the Univ. of Hawaii adaptive optics system at the UH 2.2 m telescope. Our survey detects 293 stars brighter than $K=18.2$ mag and resolves pairs to the $0.23''$ diffraction limit of the telescope. The binary fraction in the angular separation range 0.3 to $0.6''$, corresponding to 132-264 AU at 440 pc, is indistinguishable from that of the solarlike stars in the solar neighborhood. Proplyds are associated with both single stars and visual binaries. About half the stars in our sample have also been measured at V and I by Prosser et al. (1994); most these seem to be about 10^6 y old observed through moderate extinction and having some excess emission at K.

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The onset of cluster formation around Herbig Ae/Be stars

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The large body of near infrared observations presented in Testi et al. (1997; 1998) are analysed with the aim of characterizing the young stellar clusters surrounding Herbig Ae/Be stars. The results confirm the tendency of early Be stars to be surrounded by dense clusters of lower mass “companions”, while Ae stars are never found to be associated with conspicuous groups. The transition between the different environments appears to occur smoothly from Ae to Be stars without a sharp threshold.

No correlation of the richness of the stellar groups detected is found with the galactic position or the age of the central Herbig Ae/Be star.

The stellar volume densities estimated for the groups surrounding pre-main-sequence stars of intermediate mass show the transition from the low density aggregates of T Tauri stars and the dense clusters around massive stars.

Only the most massive stars ($10-20 M_{\odot}$) are found to be associated with dense ($\sim 10^3$ pc⁻³) stellar clusters. This is exactly the mass regime at which the conventional accretion scenario for isolated star formation faces theoretical problems. Thus our findings strongly supports the idea that the formation of high-mass stars is influenced by dynamical interaction in a young cluster environment.

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<http://astro.caltech.edu/~lt/preprints/preprints.html>

<http://www.arcetri.astro.it/~starform/publ1998.htm>

Silicon Chemistry in PDRs

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We consider the chemistry of silicon in photo-dissociation regions (PDRs), with special attention to the available observations of the Orion Bar. We focus on the “paradox” that fine structure emission of singly ionized silicon (Si^+) is known to be strong from such regions, whereas silicon in molecular form (and in particular SiO) is absent. We consider a number of possible explanations of this “paradox” and conclude that the most likely is that Si is in solid form at depths greater than roughly 3-4 magnitudes of visual extinction, relative to the ionization front, in regions such as the Orion Bar. We consider that direct photodesorption with a small yield is likely to be the process responsible for the ejection of a Si-containing mantle into the gas phase. Other possibilities, such as the Si being present as a component of grain ice mantles, are considered; we believe that they are less likely. We find that grain polar ice mantles are probably also destroyed in PDRs, through photodesorption, whereas thermal evaporation destroys the apolar component of ice mantles deep within the surrounding molecular cloud.

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The conductivity of dense molecular gas

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We evaluate the conductivity tensor for molecular gas at densities ranging from 10^4 to 10^{15} cm^{-3} for a variety of grain models. The Hall contribution to the conductivity has generally been neglected in treatments of the dynamics of molecular gas. We find that it is not important if only $0.1 \mu\text{m}$ grains are considered, but for a Mathis-Rumpl-Nordsieck grain-size distribution (with or without PAHs) it becomes important for densities between 10^7 and 10^{11} cm^{-3} . If PAHs are included, this range is reduced to 10^9 – 10^{10} cm^{-3} .

The consequences for the magnetic field evolution and dynamics of dense molecular gas are profound. To illustrate this, we consider the propagation of Alfvén waves under these conditions. A linear analysis yields a dispersion relation valid for frequencies below the neutral collision frequencies of the charged species. The dispersion relation shows that there is a pair of circularly polarised modes with distinct propagation speeds and damping rates. We note that the gravitational collapse of dense cloud cores may be substantially modified by the Hall term.

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Preprint available at <http://xxx.lanl.gov/astro-ph/9810468>

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Dissertation Abstracts

Seeing the Light Through the Dark Infrared Dust Extinction and the Structure of Molecular Clouds

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Ph.D dissertation directed by: Charles Lada

To understand the structure of molecular clouds is to understand the initial conditions of present day star and planet formation. The goal of this thesis is the development of a new observational approach, introduced by Lada et al. (1994), to study the structure of molecular clouds. This new approach uses infrared dust extinction of starlight to construct high resolution maps of the distribution of dust inside molecular clouds over unprecedented ranges of cloud depth: $1 < A_V < 40$ magnitudes. We start by testing the robustness of the technique, proceed to derive maps of dust column density from large scale near-infrared observations of two molecular clouds in Cygnus, and through data modeling and comparison with molecular–line and dust emission data, study their physical and chemical structure.

We find that the molecular clouds studied have a strikingly similar general structure, being both centrally condensed and characterized by a volume density profile $\rho(r) \propto r^{-2}$ orthogonal to their major axes, over the entire spatial scale of the surveys ($0.1 \leq r \leq 1$ pc). Through Monte Carlo modeling of cloud density distribution we investigate the structure of these clouds on size scales smaller than the effective resolution of our maps and conclude that the observables can be explained as a natural consequence of a smooth volume density gradient, as the one that characterize these clouds, without the need for random fluctuations in their small scale structure.

Comparison of the dust extinction with $C^{18}O$ molecular emission reveals a good linear correlation between these two column density tracers for cloud depths corresponding to $A_V \leq 10$ magnitudes. For cloud depths above this threshold there is a notable break in the linear correlation most likely due, as supported by $C^{17}O$ observations in one cloud, to the depletion of $C^{18}O$ onto dust within the dense, $n \geq 10^4$ cm^{-3} , and cold, $T_{dust} \leq 15$ K, $T_{gas} \sim 10$ K regions of the clouds. In regions of very high extinction ($A_V > 10$ mag), such as dense cores, our results suggest that $C^{18}O$ would be a very poor tracer of mass. Consequently, using $C^{18}O$ as a column density tracer in molecular clouds can lead to a 10 to 30% underestimation of overall cloud mass.

Comparison of dust extinction with dust emission for one of the clouds allows us to derive the ratio of the visual extinction coefficient, κ_V , to the 1.2mm grain absorption coefficient $\kappa_{1.2}$ [$(4 \pm 2) \times 10^4$], or equivalently the temperature distribution of grains in this cloud. We find that the ratio of millimeter grain emissivity to visual extinction, $S_{1.2}/A_V$, varies roughly inversely with the visual extinction and interpret this as implying a gradient in dust temperature from roughly 8 K in the dense interior ($A_V > 20$ mag) to 20 K in regions of low (~ 5 mag) extinction. A consequence of this result is that the 1.2 mm intensity is not, by itself, a good tracer of mass in the studied cloud.

The work in this thesis represents the establishment of a new observational approach using infrared dust extinction to study molecular cloud structure. Making use of the lessons learned in this dissertation, we suggest possible future paths of research towards a better understanding of molecular clouds and of the structure of the disk of the Galaxy where these clouds live and evolve.

CO-ices in embedded Young Stellar Objects

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Ph.D dissertation directed by: Dr. J.P. Emerson

Ph.D degree awarded: September 1998

Stars are born in dense cores within molecular clouds, enshrouded in large cocoons of gas and dust which completely obscure the forming star. The large degree of obscuration towards the young stars is due to the presence of solid dust grains in their circumstellar envelopes, which efficiently absorb the radiation from the star at visual and ultraviolet wavelengths, reradiating that energy at far-infrared and submillimeter wavelengths. The composition and structure of the dust grains is not well known, but current studies point to grains having a refractory core and acquiring ice mantles in the cool, shielded conditions of molecular clouds. Such ice mantles are the subject of this thesis.

Infrared spectroscopy is an important tool in the study of the complex ice mantles on interstellar grains. A variety of absorption features at these wavelengths, which have been identified as the vibrational transitions of the molecules in the ices, can provide important information on the composition, structure and evolution of the grains.

The work reported in this thesis consists of an observational study of the composition of the ice mantles acquired by the dust grains in molecular clouds (with particular emphasis on the CO-ices in the material surrounding embedded Young Stellar Objects in nearby molecular clouds), what can be learned from that about the physical conditions in the regions where the ice mantles exist, and what may affect their survival and evolution.

In this work, spectra of the $4.67\ \mu\text{m}$ solid CO absorption feature are presented, mostly towards embedded objects in Taurus. The thesis starts with a brief overview of technical aspects of spectroscopic observations at thermal infrared wavelengths, where the CO stretch absorption feature is located. The observations and data reduction procedures are then reported and discussed in detail. The likely composition of the CO-bearing ices is analysed by fitting the observations with laboratory data. The statistical significance of the results is discussed. Excellent fits to the nonpolar component of the CO-ices along the observed lines-of-sight are produced with ion irradiated pure CO ices. The possible origin of the ion irradiation is discussed, covering flares on the YSOs, cosmic rays and X-ray and UV processing. Predictions are made for the abundance of CO₂ and methanol in the mantles. Furthermore, a comparison is made between the results of observations of CO and H₂O ices towards the Taurus and Ophiuchus dark clouds. The column densities of the ices are compared with the visual extinction, A_v , through the clouds, and with the 1.3 mm continuum emission from the YSOs. The inclusion of the objects in Taurus observed in this work resulted in the appearance of a discontinuity in the relation between the water-ice column density and A_v , at the value of A_v for which the optical depth at $3\ \mu\text{m}$ (the wavelength of the water-ice absorption feature) is unity. Finally, all the observations and results discussed throughout the thesis are brought together to address their implications in the current understanding of the conditions in Taurus and Ophiuchus.

Thesis and published paper available at <http://www.obs.aau.dk/~tct/>

New Jobs

Research Associate Position

ARECIBO OBSERVATORY–NATIONAL ASTRONOMY AND IONOSPHERE CENTER

Attention: Dr. Paul F. Goldsmith

The National Astronomy and Ionosphere Center (NAIC) has an opening for a staff Research Associate in radio astronomy at the Arecibo Observatory, Puerto Rico. The facility is an NSF-funded National Observatory for research in radio and radar astronomy, and in atmospheric science, accepting observing proposals from scientists worldwide. The Arecibo 305-m reflecting telescope has recently been upgraded with a Gregorian reflector system and instrumentation which permits observations within a frequency range spanning 300 MHz to 10 GHz. This upgrade has resulted in significant improvements in available bandwidths, system noise and gain. The successful candidate will have the opportunity to capitalize on these improved capabilities.

The Arecibo Observatory is located in the karst hills of the beautiful Caribbean island of Puerto Rico. A stimulating research environment is provided by approximately 25 resident staff scientists, postdoctoral fellows and graduate students, as well as over 200 visiting scientists per year. In addition, physics and engineering faculty and students of the University of Puerto Rico have a cooperative research and educational association with the Observatory.

All applicants whose research interests include any field of radio astronomy that can be exploited with the Arecibo telescope will be considered for the positions. We particularly encourage applications from individuals who are actively involved in investigation of the interstellar medium in the Milky Way and external galaxies using the 21-cm spectral line of neutral hydrogen and other atomic and molecular probes. Besides conducting an independent research program, on-site staff scientists are expected to advise visiting scientists in all aspects of their observations, and to help define and implement improvements in equipment, observing procedures and data reduction.

A Ph.D. in astronomy or a related field is required. These staff appointments are initially made for a period of two years. Upon review, a Research Associate may be reappointed for an additional three years, at which time promotion to Senior Research Associate and longer-term reappointment may be considered. Salary and benefits are competitive, attractive and include educational and relocation allowances. Details will depend upon an applicant's qualifications and experience. Please submit the application by December 1, 1998, including a complete resume of academic, professional and personal data, and the names of at least three references, to: The Director, National Astronomy and Ionosphere Center, Cornell University, Space Sciences Building, Ithaca, NY 14853-6801. EOE/AAE. For further information about NAIC and the Arecibo Observatory see <http://www.naic.edu>.

New Books

From Stardust to Planetesimals

Edited by Y.J. Pendleton and A.G.G.M. Tielens

These are the proceedings of a meeting focused on the processes involved in the evolution from stardust to planetesimals, bringing together astronomers interested in star- and planet-formation, planetary scientists studying the early solar system, and meteoriticists and laboratory scientists interested in meteorites and interplanetary dust particles.

The following lists the sections and chapters of the book.

The Formation of Planetary Systems

The Role of Dust in Star and Planet Formation: Observations *C.J. Chandler & A.I. Sargent*

The Role of Dust in Star and Planet Formation: Theory *P. Bodenheimer*

Exploring Planetary Debris around Solar-Type Stars *D.E. Backman, M.W. Werner, G.H. Rieke & J.E. Van Cleve*

First ISO-SWS Results: From Stardust to Planetesimals *C. Waelkens & L.B.F.M. Waters*

The Lifecycle of Interstellar Dust

Depletions and Interstellar Dust *U.J. Sofia*

Composition and Size of Interstellar Dust *J.S. Mathis*

The Lifecycle of Interstellar Dust *A.P. Jones*

Formation of Carbon Particles in Cosmic Environments *M. Frenklach & E. Feigelson*

Large Interstellar Molecules

Spectroscopy of the Unidentified Infrared Emission Bands *T.R. Geballe*

The PAH Hypothesis: Infrared Spectroscopic Properties of PAHs *L. d'Hendecourt*

The Diffuse Interstellar Bands and Large Interstellar Molecules *T. P. Snow*

Interstellar Ices and Organics

Infrared Observations of Interstellar Absorption Features *D.C.B. Whittet & A.G.G.M. Tielens*

The Nature and Evolution of Interstellar Organics *Y.J. Pendleton & J.E. Chiar*

The Composition and Ultraviolet and Thermal Processing of Interstellar Ices *S.A. Sandford, L.A. Allamandola & M.P. Bernstein*

Dust in the Solar System

GEMS and other Pre-accretional Irradiated Grains in Interplanetary Dust Particles *J.P. Bradley, D.E. Brownlee & T.P. Snow*

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Stardust to Planetesimals: A Chondrule Connection? *J. Paque & T. Bunch*

The Formation of Planetesimals

Processing of Material in the Solar Nebula *J.I. Lunine*

Planetesimals from Stardust *S.J. Weidenschilling*

Coagulation Experiments *J. Blum*

Kuiper Belt objects

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The Kuiper Belt *D. Jewitt & J. Luu*

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The Composition of Comets

Organic Volatiles in Comets: Their Relation to Interstellar Ices and Solar Nebula Material *M. J. Mumma*

Chemistry and Mineralogy of Comet Halley's Dust *H. Schulze, J. Kissel & E. K. Jessberger*

Organic Components of Cometary Dust *M. N. Fomenkova*

Ice Bombardment of Comets *G. Strazzulla*

From Planetesimals to Planets: Contributions of Icy Planetesimals to Planetary Atmospheres *T.C. Owen*

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Star Formation with the Infrared Space Observatory (ISO)

Edited by J.L. Yun and R. Liseau

These are the proceedings of a meeting held in Portugal in June 1997 and devoted to early or preliminary results from the Infrared Space Observatory. The following lists the various sections and the lead chapters in each section.

1. Introduction

ISO Results on Star Formation and Interstellar Medium Studies *P. Cox*

2. Physics and Chemistry of the ISM

The Nature of Small Interstellar Dust Particles *F. Boulanger et al.*

3. Massive Star Formation and Star Formation in Nearby Galaxies

The ISM in Starburst Galaxies: Constraints from ISO Spectroscopy *D. Lutz et al.*

4. ISO Surveys of Nearby Star Formation Regions

ISOCAM Survey of Nearby Star Formation Regions *L. Nordh et al.*

5. Dense Cores and Protostars

Young Protostars and Inward Motions in Low-Mass Dense Cores *P.C. Myers & D. Mardones*

6. Jets and Outflows

LWS Observations of Pre-Main Sequence Objects *P. Saraceno et al.*

7. Circumstellar Environments

Circumstellar Disks around Pre-Main Sequence Stars: What ISO can tell us *A. Natta, M.R. Meyer & S.V.W. Beckwith*

8. Poster Papers

Astronomical Society of the Pacific Conference Series Vol. 132
ISBN 1-886733-52-X - 448 pages - Published 1998
Price and ordering information, see above.

Solar System Formation and Evolution

Edited by D. Lazzaro et al.

These are the proceedings of a meeting held in Rio de Janeiro in November 1997, focused on studies of the formation of the Solar System, and on what can be deduced about its evolution through studies of its current structure and composition. The following lists the various chapters.

Formation of Planetary Systems *J.J. Lissauer*

Extra-solar Planets *B. Sicardy*

Indication of Disk Accretion on Low Mass Pre-Main Sequence Stars *C. Batalha & K. Dewulsky*

Orbital Resonances and Chaos in the Solar System *R. Malhotra*

Chaos, Diffusion, Escape and Permanence of Resonant Asteroids in Gaps and Groups *S. Ferraz-Mello, D. Nesvornyy & T.A. Michtchenko*

The Structure of the Kuiper Belt and the Origin of Jupiter-Family Comets *A. Morbidelli*

Origin and Evolution of the Oort Cloud *J.A. Fernandez & A. Brunini*

Comets Hale-Bopp and Hyakutake: Records of Presolar Chemistry and more *H. Campins*

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Tidal Stresses on Europa: Celestial Mechanics meets Geology *R. Greenberg et al.*

Dynamics of Planetary Rings *P.D. Nicholson*

Nonthermal Radio Emissions of the Solar System *A.C.L. Chian*

Astronomical Society of the Pacific Conference Series Vol. 149

ISBN 1-886733-52-X - 194 pages - Published 1998

Price and ordering information, see above.

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, where you can access it via the ESO Portal (<http://http.hq.eso.org/eso-homepage.html>). You can also access it through the University of Massachusetts Astronomy World Wide Web server, the URL for its home page is <http://www-astro.phast.umass.edu/>

Announcements

Star Formation Research with NGST

Dear Colleagues:

As many of you know, the Next Generation Space Telescope (NGST) is one of the highest priority missions in the NASA Origins program for the coming decade (for information concerning the NGST project please see <http://ngst.gsfc.nasa.gov/>). For the past year I have served on the NGST Ad Hoc Science Working Group (ASWG) charged with representing the research community interested in star and planet formation. As part of an exercise to help define the capabilities needed to insure that NGST has maximum impact in our field when it is launched in 2008, Joan Najita (NOAO) and I have organized the NGST Star and Planet Formation Study Group, consisting of ~ 12 members representing a range of interests and backgrounds. We have created a preliminary suite of research programs that can only be undertaken with such a facility. We invite everyone to visit our WWW site at: <http://nimbus.as.arizona.edu:8000/~mmeyer/ngst.html>. There you will find a copy of our thematic summary of origins-related research, as well as a description of the five programs we have put forward to be included in the NGST Design Reference Mission. Note that our proposals explicitly exclude solar system topics (coordinated by Phil Nicholson of Cornell) and stellar populations studies of the Milky Way and local group galaxies (coordinated by Michael Rich of UCLA). We invite comment on these programs in the coming months as we revise them in preparation for submission to the relevant decadal survey committees. There will also be an open forum concerning NGST at the upcoming AAS meeting in January and several posters devoted to science programs with NGST. Everyone is encouraged to attend and express their opinions concerning NGST. If you have any questions or concerns regarding NGST, please do not hesitate to contact me.

Sincerely,

Michael R. Meyer

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<http://nimbus.as.arizona.edu:8000/~mmeyer/ngst.html>