dust. We did not find gas associated with DG Tau. However, gas has been found around LkHα 234 and T-Tauri itself I see no reason why further surveys should not reveal more such sources.

THOMPSON: Since HL Tau shows strong Brγ, Brα and Balmer emission lines, how did you determine that the radio continuum was not optically thick or thin free-free emission?

SARGENT: Using the value of the Brα flux derived by Persson *et al.* we calculated the expected flux at 2.7 mm, assuming the continuum emission to arise from free-free radiation from dust. The value derived, 30 m Jy, is quite incompatible with our measured value of 100 m Jy.

STROM: Could you provide a limit on the gas to dust ratio in the HL Tau disk?

SARGENT: The gas mass we deduce is only a lower limit. If the emission is optically thick, or if the source is much smaller than our beam, the mass will be higher and, as a result, close to the mass calculated from the observed continuum flux using Hildegrand's (1984) methods and assumptions. It would be premature to make any predictions about the gas to dust ratio in the disk on the basis of the measurements so far.

POLARIZATION OBSERVATIONS IN THE NEAR INFRARED AS A PROBE OF BIPOLAR FLOW REGIONS

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It is shown that near infrared polarization is to be expected in star-forming regions and new observations with the UK Infrared Telescope (UKIRT) are reported which include the discovery of a molecular hydrogen reflection nebula in Orion and an extensive dust cloud around S106.

Star-forming regions are dusty/gaseous environments with embedded sources which are heavily obscured at optical wavelengths. At longer wavelengths, however, the scattering optical depth $\tau_{sca}(\lambda)$ decreases and for $\tau_{sca} < 1$ then dust particles with a substantial albedo (ω) are efficient polarizers.

Provided line-of-sight integration of scattered light is minimal then reflection nebulae exhibiting large polarization should occur in the near infrared. Of course, one would like to use the observed polarization as a diagnostic of the dust but it is interesting to invert the problem and check the initial conditions. By expressing the scattering optical depth (τ_{sca}) in terms of the grain scattering efficiency (Q_{sca}) and the column density of molecular hydrogen N_{H_2} we have

$$\tau_{sca}(\lambda) = 3/4 \left(\frac{Q_{sca}(\lambda)}{a}\right) \frac{X m_{H_2} N_{H_2}}{\rho}$$

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Substituting reasonable grain parameters for a wavelength of 2 μm, a dust/gas mass ratio of X = 10^{-2} and a path length of 0.3 pc then the space density of H_2 lies in the range 10^3 - 10^5 cm^{-3} for 0.01 < τ (2 μm) < 1.

The importance of polarization observations as a function of wavelength and position (mapping) lies in the fact that both physical and geometrical information is revealed. In particular, polarimetry yields: (i) the location of obscured centres of illumination; (ii) the geometry of outflows; (iii) the distribution of gas and dust; (iv) the size and composition of the scatterers; and (v) the influence of magnetic fields on grain alignment.

An extremely important example of the application of infrared polarimetry are the new observations of the Orion-KL nebula presented recently by Hough *et al.* (1986). Using the AAT, high spatial resolution maps (2.5") were made in broad bands at K(2.2 μm) and L'(3.8 μm). These were followed up by lower resolution (19.6") maps at K for the much fainter outer regions by using the UKT9 photometer and the Kyoto polarimeter on UKIRT. Furthermore, using UKIRT, the polarization in the V = 1-0 S(1) emission line of molecular hydrogen (2.122 μm) was mapped over the entire region. Figure 1 shows the S(1) line data. Toward the core of the region the electric vectors are roughly aligned parallel to the outflow direction whereas outside this region the vectors are centro-symmetric around Peak 1. That is, much of the H_2 emission is simply scattered radiation from Peak 1. Dichroic absorption due to aligned grains is invoked to explain the core region.

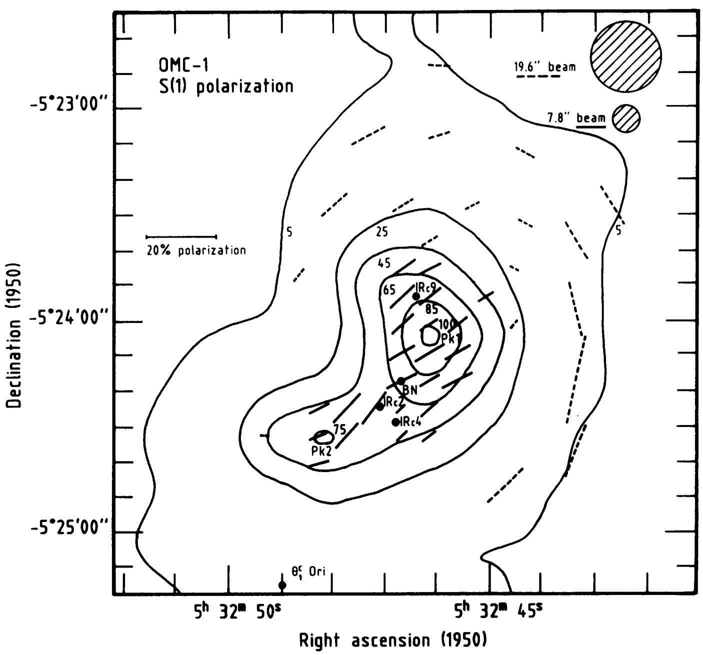

Fig. 1

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Another example, shown in Figure 2, is the work of McLean *et al.* (1986) on S106. Observations with UKIRT using a 19.6" beam revealed an extensive centro-symmetric pattern which also crosses the region of the optical dark lane. These data imply that the source is compact and that the dust lane is optically thin at 2 μm. The observed surface brightness of polarized flux is an additional constraint on the illuminating source. In fact, the source of the 2 μm flux cannot be the O9-B0 star itself, unless the grain albedo is ∿ 100%,but is more readily ascribed to the observed infrared source IRS4.

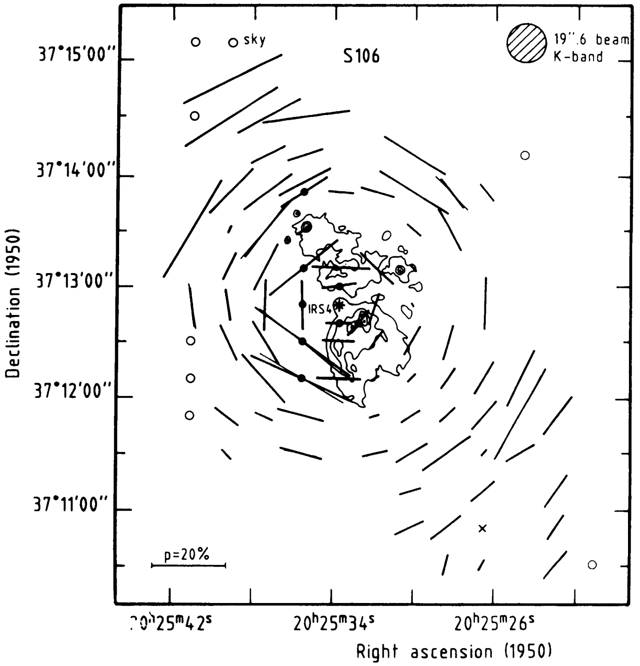

Fig. 2

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