N87-15051

Are Young Stars Always Associated with Cold Massive Disks? A CO and Millimeter Interferometric Continuum Survey

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We present the results of a combined millimeter-wave spectral-line and continuum survey of cold far-infrared sources selected to favor embedded young stars in the Galaxy. The spectral-line observations were performed with the 5 meter antenna of the University of Texas Millimeter-Wave Observatory. High resolution continuum observations were obtained with the Owens Valley (OVRO) Millimeter-Wave Interferometer. The goal of the survey was to gain insight into the mass, temperature, and distribution of cold dust which envelopes stars during the earliest stages of their evolution.

The sample for our survey was drawn from the IRAS point source catalog. Our selection criteria were: 1) the source color temperature as measured by the IRAS 25 μm and 60 μm bands was < 75 K, 2) the source lies between 2 and 25 degrees of the galactic plane at declinations north of -30 degrees, 3) the source has measured fluxes in at least 3 of the 4 IRAS bands, 4) the source was not identified as a main sequence or evolved star, a planetary nebulae, or extragalactic object in the IRAS catalog, and 5) the flux at 60 μm was >100 Jy. The initial sample consisted of 85 sources. Nearly one-half of these could be eliminated based upon identification with H II regions, reflection nebulae, planetary nebulae, externally heated clouds, and emission-line or reddened visible stars. The remaining 48 objects constitute our sample of potential young stellar objects and include some well-studied sources such as S140 and Cep A.

The first phase of our survey involved 1.2 arcmin resolution observations of ^{12}CO and ^{13}CO emission lines toward each source. All but two sources had detectable CO emission. We found that 40 % of the sources appear to be associated with star formation as evidenced by the presence of enhanced ^{12}CO line widths or broad wings (V = 20-50 km s^{-1}). At least five of these objects are associated with bipolar molecular outflows (IRAS 05338-0624, L1689N, IRAS 20126+4104, S140, and Cep A).

The second phase of our survey involves high resolution 2.7 mm continuum observations with 3 interferometer baselines ranging from 15 to 55 m in length. Preliminary results indicate that about 25 % of the sources in our sample have detectable continuum emission on scales less than 30 arcsec. The flux limit of the survey is roughly 100 mJy which corresponds to a gas and dust mass limit of 5 $M_\odot$ (50 K / T_{dust}) D^2_{kpc} for a λ^{-1} dust emissivity law. The mass limit for a λ^{-2} emissivity law is a factor of 7 larger.

The high percentage of sources with enhanced ^{12}CO line widths or broad wings indicates that a significant fraction of our sample, ~40%, are likely to be young stars. The lower detection percentage in the continuum observations, ~25%, suggests that such objects not always surrounded by large concentrations of gas and dust. The continuum detection percentage for actual dust emission could be lower than that given above since emission from ionized gas could be responsible for the observed 2.7 mm emission in some objects.

To get an understanding of the type of object detected in our survey, a 4" x 6" resolution map of one of the survey sources, L1689N, has been made using the OVRO mm interferometer. This object shows strong (0.6 Jy) 2.7 mm emission from a 13" x <6" (2100 x <1000 AU) region roughly centered on the IRAS point source position, IRAS 16293-2422. Based on a λ^{-1} emissivity law and a dust temperature of 38 K (Walker *et al.* 1986), the source contains ~1 $M_{\odot}$ of gas and dust. The position angle of the 2.7 mm emission is approximately 30° west of north which is perpendicular to the large scale magnetic field direction as defined by polarization measurements (Vrba, Strom, and Strom 1978) and roughly perpendicular to the CO outflow centered near this source (Wootten and Loren 1986; Walker *et al.* 1986). ^{13}CO line observations from the interferometer suggest that the structure may be rotating at ~2 km s^{-1} about an axis aligned with the magnetic field, perpendicular to the major axis of the observed continuum emission. Further observations will be need to confirm this possible rotation and thereby identify the dust structure as a circumstellar disk.

References

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