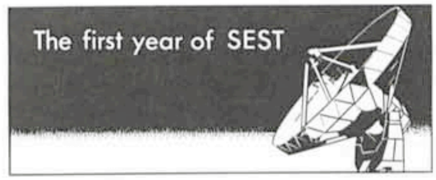

Low-Mass Star-Forming Regions

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While high-mass star formation is a dramatic process visible throughout large parts of our Galaxy, the formation of low-mass solar-type stars involves much more modest phenomena. But because low-mass stars are so much more common than high-mass stars, it is possible to find molecular clouds with abundant young low-mass stars at distances as small as 100 to 200 pc.

Of the five closest stellar nurseries, four are located in the southern Milky Way, namely the Chamaeleon, Lupus, Ophiuchus and Corona Australis cloud complexes. Of these, the Ophiuchus and Corona Australis cloud complexes are just within reach of mid-latitude northern radio telescopes. At La Silla, however, they pass through the zenith.

It is therefore not surprising that the arrival of the SEST at La Silla has been anxiously awaited by the low-mass star-formation community, and that through the first year of operation, SEST has been used for intense studies of southern low-mass star-forming regions. A few of these studies are reported in the following.

At declinations between −70° and −80°, the Chamaeleon clouds are virgin territory for millimetre observations at the resolution provided by the SEST. They are also at a rather high galactic latitude (b = −16°), so most of the confusion with background clouds in the galactic plane is avoided. And, finally, at a distance of only 140 pc, they are among the very closest of star-forming clouds. Kalevi Mattila and associates at Helsinki Observatory have embarked on a large-scale survey of the northern half of the Chamaeleon I cloud. Here, five young low-mass stars are clustered around HD 97300, a B9V star surrounded by a bright reflection nebula.

Mattila and co-workers mapped the cloud structure by observing $C^{18}O$ in frequency-switching mode, and found a dense molecular core centred on the young stars. The area was also mapped in the ^{13}CO line, but it appears to be optically thick over most of the field observed.

Maps in ^{12}CO have revealed a large molecular outflow, with well-defined blue and red wings outlining a bipolar flow and centred on the region of young stars (see Fig. 1). The total angular extent of the flow is about 14 arcminutes, corresponding to a projected length of almost 0.6 pc. Closer examination of the data shows that the outflow is not associated with HD 97300, but rather with one of the less luminous pre-main sequence stars. It appears that the star-formation efficiency of the cloud core is around 25 %.

In recent years much attention has been paid to the high-latitude clouds, relatively diffuse molecular clouds at high galactic latitudes and often very nearby. Jan Brand, Jan Wouterloot and Loris Magnani have studied L 1569, a high-latitude (b = −36°) cloud on the celestial equator between Eridanus and Taurus. They first used the ESO 3.6-m telescope with a grism to search for faint H-alpha emission stars projected on the cloud. Five such stars were found. Subsequently, SEST was employed to map part of the cloud in ^{12}CO and ^{13}CO in a study of cloud structure and possible interaction between the stars and their ambient medium. The cloud appears clumpy, with core sizes of approximately 0.05 pc. An interesting feature is that low-intensity wings of the line profiles are present, also in parts of the cloud away from the H-alpha emission stars. Recently, such puzzling wings have been found in several other high-latitude clouds without internal energy sources; their origins are not yet properly understood.

Molecular clouds with Herbig-Haro objects were among the first regions to be observed with the SEST. Michael Olberg and Roy Booth of Onsala Space Observatory and myself have studied a number of such regions in various tran-

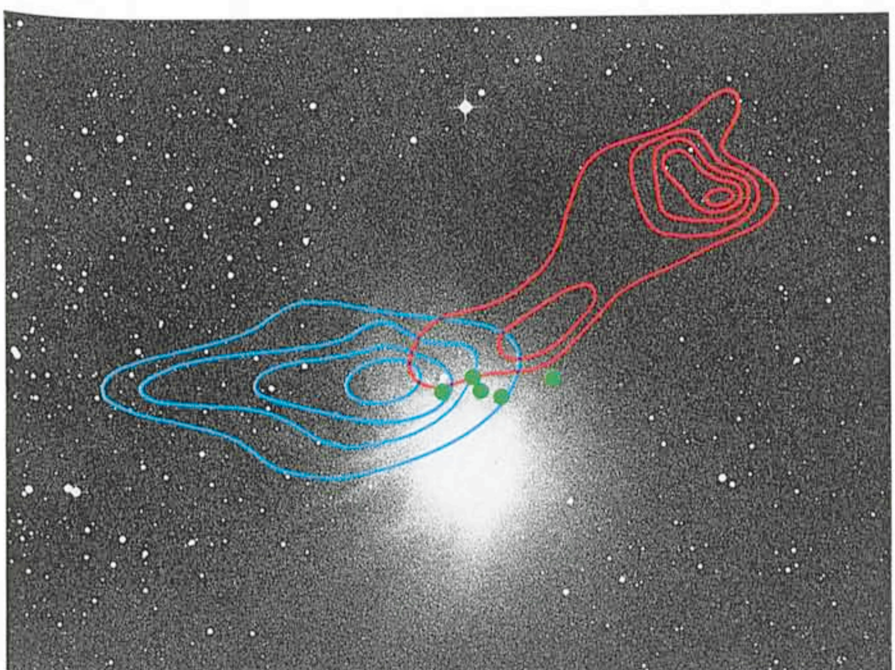

Figure 1: *A composite figure showing the blue and red lobes of a major molecular outflow in the northern part of the Chamaeleon I cloud. Young stars are indicated by dots. The bright nebulous star is HD 97300, a B9V star unrelated to the flow. The underlying photograph is reproduced from a blue ESO Schmidt plate. North is up and East is left. Courtesy K. Mattila and C. Madsen.*

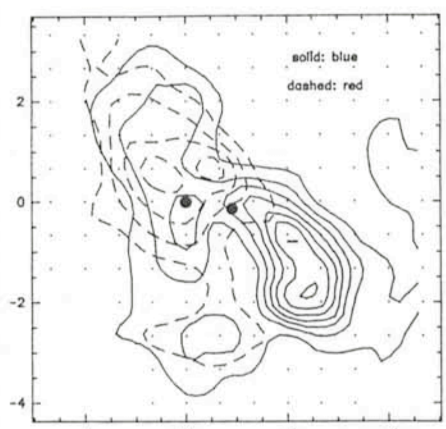

Figure 2: *A contour diagram of the two molecular outflows associated with the Herbig-Haro objects HH 56 and 57. The positions of the two driving energy sources are indicated. Solid lines are the blue lobes, dashed lines are the red lobes. The HH 56 flow is to the right, the HH 57 flow to the left. North is up and East is left.*

sitions. One of the most interesting regions is located in a small cloud in Norma, containing the Herbig-Haro objects HH 56 and 57 (see centrefold of the *Messenger* No. 52). Each of these objects is powered by a separate energy source; the one associated with HH 57 belongs to the rare class of FU Ori stars, which are thought to be T Tauri stars in very active accretion phases.

We have detected two large molecular outflows, one from each of the energy sources (Fig. 2). The two flows are slightly inclined with respect to each other, so that the blue lobes approaching us are well separated, while the red, receding lobes are mixed or at least projected on each other. The velocities of the outflows are modest, less than 5 km/sec. The masses of the swept-up ambient material is of the order of 5 solar masses.

I have worked at La Silla during the last several years, and it has been noticeable that a new user community of radio astronomers has appeared on the mountain. It has been interesting to witness how these new users have gradually integrated into the daily life of the observatory. Because La Silla is now an optical, infrared and radio observatory, it acts as an interface between what has long been almost separate European communities of radio astronomers on the one hand and optical/infrared astronomers on the other. Many collaborations spanning the optical-infrared-millimetre regimes have been started in the restaurant at La Silla. Especially in low-mass star-formation studies such multi-wavelength programmes are of the greatest importance.

Cometary Globules

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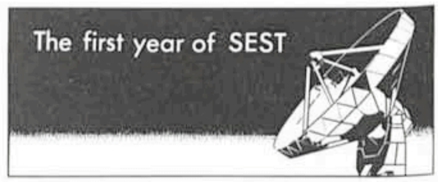

Cometary globules (CG's; see Fig. 1), first observed in 1976, are interstellar clouds with comet-like morphology, consisting of compact, dusty, and opaque heads and long, faintly luminous tails. Unlike most dark clouds, CG's are isolated neutral globules surrounded by a hot ionized medium.

Most CG's are located in the Gum nebula, a large region of ionized gas with approximate distance and size of 450 and 300 pc, respectively. Its prominent sources of energy are γ^2 Vel (WC 8+O9 I), ζ Pup (O4), and the Vela supernova remnant. Figure 2 (Zealey et al. 1983) demonstrates that the CG's are located on an annulus between 6° and 11° from "centre 1", i.e. at the boundary of the ionized bubble, with the tails pointing away from the central region.

Two scenarios were suggested to explain the spatial distribution and the comet-like appearance: Brand (1981) argues that CG's were initially nearly spherical clouds which were shocked by the blast wave from a supernova explosion. Reipurth (1983) suggests that the CG's are shaped by UV radiation impinging on a neutral cloud in a clumpy interstellar medium. Discrimination between these and other possible models is only possible, if we know the mass, density, temperature, and velocity distribution of the globules. These parameters can be determined by measurements of molecular spectral lines which are most easily accessible at mm-wavelengths.

Because of their southern location (Declinations $< -40°$), detailed maps could not be obtained until recently. The SEST telescope, however, has completely changed the situation. A number of sources have now been mapped in CO and its rarer isotopes and data from other molecules sensitive to higher densities have also been obtained. While it is too early for a systematic review,

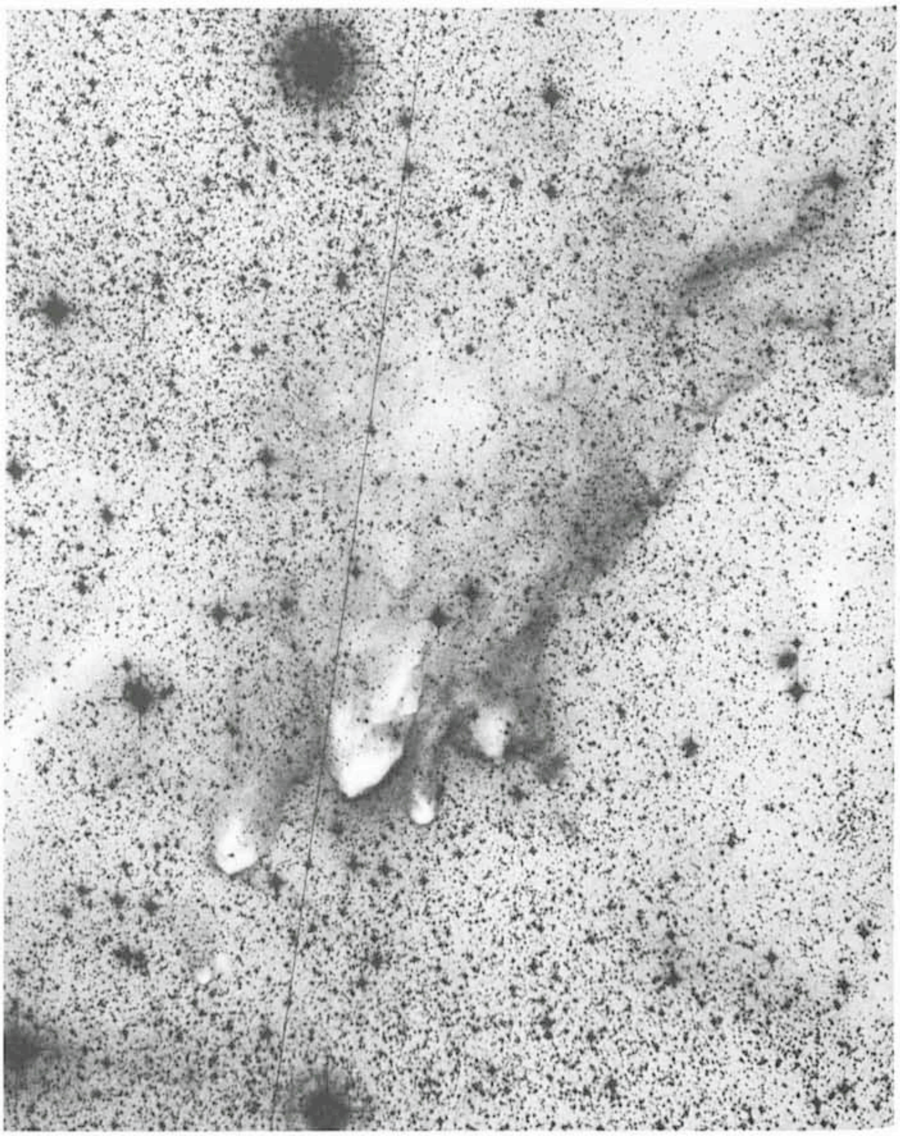

Figure 1: *An optical photograph of CG 30/31/38 (Reipurth 1983, Laustsen et al. 1987).*