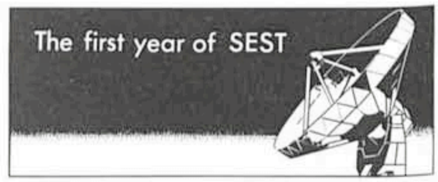
sitions. One of the most interesting regions is located in a small cloud in Norma, containing the Herbig-Haro objects HH 56 and 57 (see centrefold of the *Messenger* No. 52). Each of these objects is powered by a separate energy source; the one associated with HH 57 belongs to the rare class of FU Ori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

C. HENKEL, Max-Planck-Institut für Radioastronomie, Bonn, F. R. Germany



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,

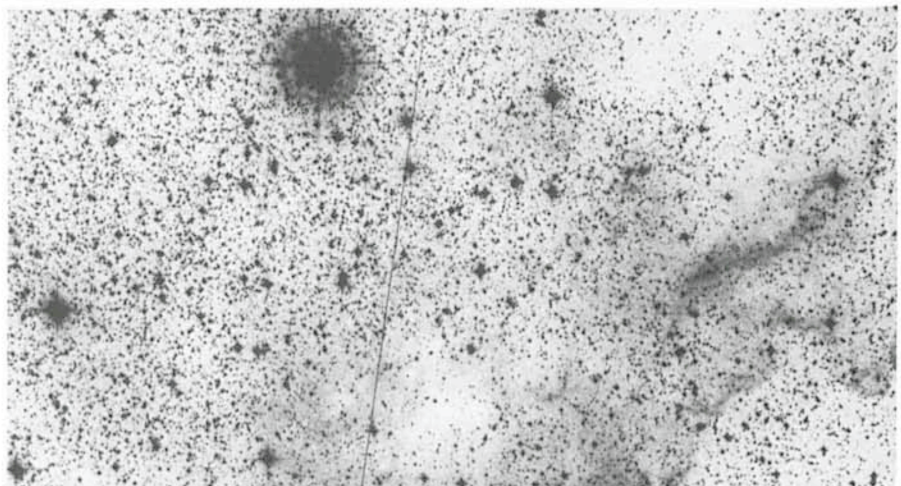


Figure 1: *An optical photograph of CG 30/31/38 (Reipurth 1983, Laustsen et al. 1987).*

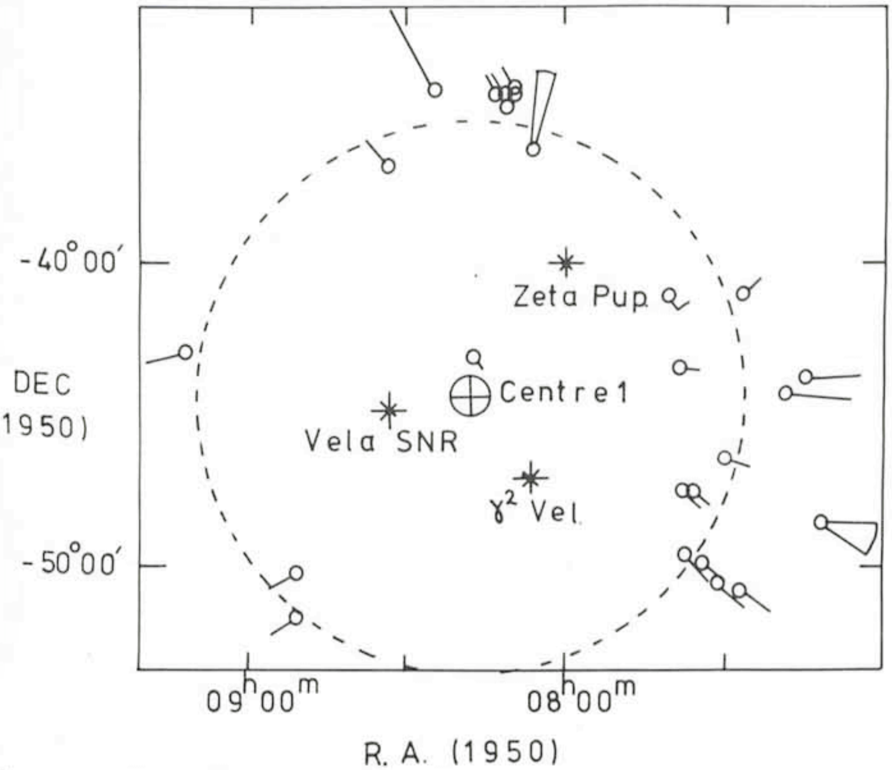


Figure 2: *The distribution of CG's in the Gum nebula, showing centre 1, the position from which most of the tails point away, and a 9 degree circle around that point (Zealey et al. 1983).*

there are already some interesting results:

So far mapped are CG 1, 15, and 21 (Harju et al. 1989), CG 4 and 6 (Cernicharo and Radford 1989), the ESO 210-6A globule, and CG 30/31/38 (Booth, Olberg, and Reipurth 1989; see Fig. 1). The data demonstrate that most of the mass of the globules is indeed in the form of molecular gas. Spectral lines allow the determination of radial velocities to an accuracy of 0.1 km s^{-1} (see the spectra in Fig. 3). They also allow estimates of excitation conditions and mass distribution.

The ESO 210-617 and CG 30/31/38 globules are of particular interest because of their association with the Herbig Haro objects, HH 46/47 and HH 120. There is a molecular outflow oriented along the direction of the optical jet which is formed by the HH 46/47 system, demonstrating the activity of one (or more) young stars formed in the globule.

CG 4 shows a high degree of clumping and a rather unsystematic velocity pattern, indicating complex structure not revealed by the optical image (e.g. Reipurth). The detection of CS in CG 4 demonstrates that number densities in excess of 10^4 cm^{-3} can be reached in such sources. Similar densities are also obtained from the "nose" of CG 1, where a second CO velocity component might indicate a shock, presumably associated with the "recently" formed star, Bernes 135.

Unlike CG 4, CG 1 (Fig. 4) shows the rather uniform picture also seen at optical wavelengths. The mass of the globule is of order 10–100 $M_\odot$, most of it located in the tail. The gas is cool, with kinetic temperatures only slightly above 10 K. CG 15 appears to be a scaled down version of CG 1, however without the second velocity component near the head and without any sign of recent star formation. CG 21, the only measured cometary globule not belonging to the Gum nebula, shows quite a complex velocity pattern with up to three or more velocity components in a single spectrum and a highly clumped tail. It hence appears that the structure of the molecular gas, responsible for the bulk of the mass, is quite heterogeneous.

A careful analysis of the molecular spectra will significantly increase our knowledge on cometary globules and will motivate further theoretical studies to elucidate their nature and history.

References

Booth, R.S., Olberg, M., Reipurth, B.: 1989, in preparation.

Brand, P.W.J.L., Hawarden, T.G., Longmore, A.J., William, P.M., Caldwell, J.A.R.: 1983, *Monthly Notices Roy. Astron. Soc.* **203,** 215.

Cernicharo, J., Radford, S.: 1989, in preparation.

Harju, J., Sahu, M., Henkel, C., Wilson, T.L., Sahu, K.C., Pottasch, S.R.: 1989, *Astron. Astrophys.*, submitted.

Laustsen, S., Madsen, C., West, R.M.: 1987, *"Exploring the Southern Sky"*, Springer Verlag.

Reipurth, B.: 1983, *Astron. Astrophys.* **117,** 183.

Zealey, W.J., Ninkov, Z., Rice, E., Hartley, M., Tritton, S.B.: 1983, *Astrophys. Letters* **23,** 119.

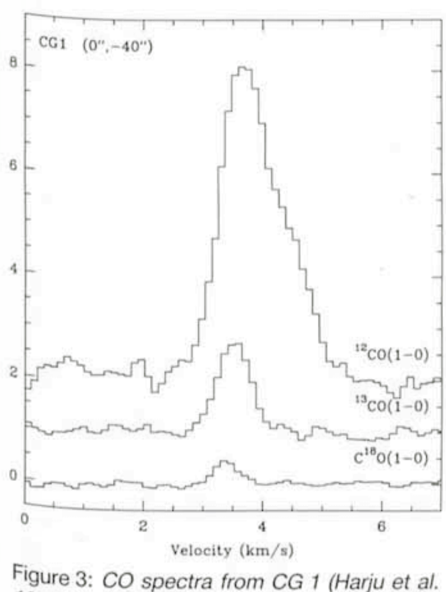


Figure 3: *CO spectra from CG 1 (Harju et al. 1989).*

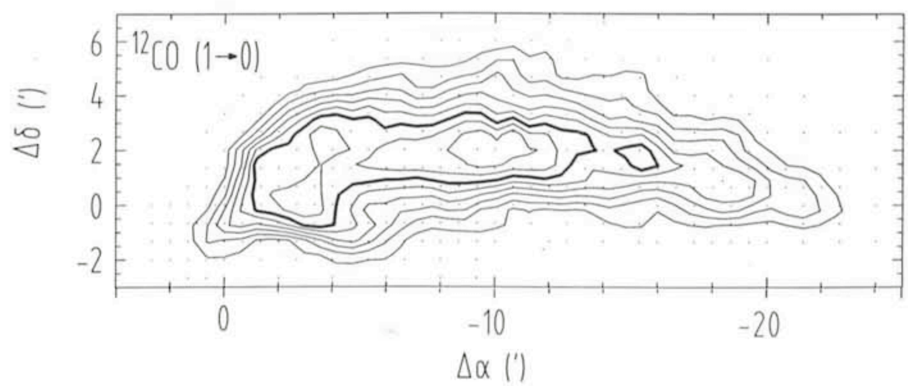


Figure 4: *A CO map of the dolphin shaped globule CG 1 (Harju et al. 1989).*