velocity difference between CO and recombination lines. There is a marked discontinuity at a velocity difference of 5 km s⁻¹. At lower values, where most of the CO is probably associated with the HII regions, the temperature (which represents lower limits of the kinetic temperatures of the clouds) can be quite high, reaching 38 K in one case; the median value is 13 K. On the other hand, at higher velocity differences, where the CO is less likely to be associated with the HII regions, the temperatures are low, averaging about 4 K. These clouds must be cooler or less dense than those near the HII regions. The conclusions are: (1) CO features with velocity differences less than or equal to 5 km s⁻¹ are representative of molecular clouds associated with HII regions; (2) the most easily detectable CO emission is associated with HII regions; therefore such emission should serve as a good indicator of spiral structure.

![Figure 3: Histograms of the number of CO lines as a function of halfwidth for: (a) cases where the velocity difference between CO line and recombination line exceeds 5 km s⁻¹; (b) cases where the difference is no greater than 5 km s⁻¹. Dashed lines indicate median values.](image)

Figure 3 shows histograms of the number of CO features as a function of CO line halfwidth for clouds that, from the previous paragraph, are classified as (a) away from and (b) near HII regions. For the latter, the median value is 9.2 km s⁻¹, considerably larger than the value (5 km s⁻¹) obtained for other molecules. High optical depths in the CO clouds could contribute to this broadening; future observations of ¹³CO (which has lower optical depths) will assist in the interpretation. For the other clouds the median is similar (10.8 km s⁻¹) but the distribution broader. This is probably caused by contributions from (a) cool dark clouds with low halfwidths, and (b) blends of separate weak features with small differences in velocity.

There is a weak correlation between CO temperature and the detected H₂CO is generally only that seen in absorption against the continuum emission of the HII region whereas the CO emission is restricted only by the size of the telescope beam.

For an HII region embedded in a gas cloud any systematic velocity variation in the cloud (a prerequisite of some cloud models — see e.g. Goldreich and Kwan (1974)) should give rise to differences between the CO, H₂O and recombination line velocities. For the velocity difference $(V_{CO}-V_{H2CO})$, the median value is $-0.3$ km s⁻¹, with quartile values of $-1.5$, $+1.7$ km s⁻¹; similar values apply to clouds not associated with HII regions. For the velocity difference $(V_{CO}-V_{recomb})$, the corresponding values are $0.0$, $-1.7$ and $+1.8$ km s⁻¹ for differences less than or equal to 5 km s⁻¹. Therefore, although systematic variations in individual clouds are not excluded there is no support for general systematic motions.

As stated at the beginning, these observations represent only the initial stage of our survey of southern CO cloud-HII region complexes. Future stages will include extensive $¹³$CO and $¹²$CO mapping of the brightest clouds, and CO observations of fainter HII regions for use in investigating the southern rotation curve of the Galaxy.

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allow this to be determined once photometric work has been completed.

Goss et al. (1980) included the central object in their survey of 6cm formaldehyde absorption in southern dark clouds, interpreting their data in terms of two components at velocities of 0.02 and 0.3 km s\(^{-1}\). These velocities are consistent with those for the OH and CH line parameters reported by Sandall et al. (1981).

The optical extinction \((A_v)\) was determined by Sandall et al. (1981) over an area approximately 1° diameter centred on L1642, the results indicating a peak value just in excess of 2.0. These authors also reported CO data of Malkamäki and Mattila through private communication, and using it along with the \(\text{H}_2\text{CO}\) data of Goss et al. to predict a molecular hydrogen space density of \(n(\text{H}_2) = 10^5\text{cm}^{-3}\) and a grain temperature of 40 K from the OH lines.

Surprisingly, little work has been carried out in the neutral hydrogen distribution in this region and consequently the likely validity of the predictions relating to molecular hydrogen are hard to assess.

As part of our continuing programme of research on radio spectral line studies of dark clouds we included L1642 in a recent survey. The cloud is attractive since the molecular work clearly identified the velocity range in which we might expect any associated features to occur.

**Results**

The observations were carried out over a period January 1980 - May 1981, using the room temperature 21cm radiometer on the 64m Parkes radiotelescope. Beam spacings were never greater than the telescope beam width (15') and in the immediate vicinity of L1642 a 5' interval was used. The velocity resolution was at all times better than 0.2 km s\(^{-1}\).

The observed spectrum typically consists of three well resolved components as shown in Figure 1. The central component occurs at velocities in the range 0-1 km s\(^{-1}\) over most of the extended visible object. This is identical to that for the molecular lines and in the following we assume that this component may be associated with the dust gas complex containing L1642.

The central line shape was determined from the complete spectrum by fitting the central region to the sum of three Gaussian components. The central peak fits a Gaussian profile over most of the object. In some positions however, a second small component on the side of the central line made line fitting more complex. This component is clearly resolved in a small area of the object close to that at which the spectrum in Figure 1 was obtained and indeed a residual contribution from this component can be seen in that figure. The maximum intensity is never greater than 25% of that of the central peak. Its origin is unclear and will not be considered again in this paper.

The morphology of the object as viewed in this low velocity component is shown in Figure 2. As may be seen, the gas distribution is clearly defined in all but the NE edge where a bifurcated tail like extension is visible.

Figure 1. A typical HI line profile of antenna temperature versus radial velocity (rel. LSR) in the vicinity of L1642. The small peak evident on the high velocity side of the central component is a residual of the small fourth component referred to in the text.
Figure 3. The spatial distribution of a) the radial gas velocity and b) the line width (FWHM) as determined from central component. The thin solid line corresponds to the $N_H = 1.8 \times 10^7$ atoms cm$^{-2}$ contour from Figure 2 and the broken line is the visual boundary of the nebulosity region.

Figure 4. The velocity-RA contours for the central component at $\delta = -14^\circ 20$. The development of the increased recession flow towards the E edge of the object is clearly visible. The contour levels are in antenna temperature (K).

are shown in Figures 3(a) and (b). The generally low recessional velocity is evident from this figure as also is the rapid development of a shearing flow in the N, E, and SE regions of the object. This increase in velocity corresponds to the gas at the edges of the object, where also the line widths show a clear maximum. The rapid onset of the shearing flow is clear from the ($v$-RA) variation of Figure 4 taken at a declination $\delta = -14^\circ 20$.

Discussion
The overall behaviour of the low velocity hydrogen shown in Figures 2 and 3 suggests that we are seeing a large spherical mass of gas with a small recessional velocity ($< 1$ km s$^{-1}$). This overall cloud is being subjected to a perturbing force which is causing mass flow along more than half its perimeter. This mass flow is also recessional and the velocity gradient corresponds to approximately 5 km s$^{-1}$ per projected degree. If the cloud distance were 100 pc, this would be 3 km s$^{-1}$ pc$^{-1}$ projected on the sky. The highest gradient occurs in the NE sector where Figure 2 shows the development of an extended tail. There is no sign of this increased velocity flow down most of the W. side of the cloud.

This overall behaviour can be envisaged in terms of cometary structure seen at an angle from the axis. In such a structure, what may have been originally a spherical cloud of dust and gas is perturbed by the relative motion of the general interstellar medium (i.s.m.) and the cloud. This perturbation may occur either by virtue of motion of the cloud in an otherwise static i.s.m. or as the result of the passage of a shock or blast wave through the local medium. In either case gas and dust are swept past the sides of the original cloud and lead to the development of an extended tail. (See Hawarden and Brand (1976) for descriptions of cometary globules in the Gum Nebula.)

Seen from the front, the HI distribution would be expected to show an increased flow velocity around the periphery of the object relative to the velocity of the centre. From any other angle, this shearing flow distribution would become asymmetric because of line of sight effects relative to the gas flow direction. Under these conditions it is possible that all evidence for recessional flow may disappear in regions of the object for which the gas is streaming normally to the line of sight. This may be the case on the W. side referred to above.

The location of the dust in such an object can not be reasonably predicted since it depends both on the detailed gas flows and mass distribution in the cloud. Provided that some ionization is present and the grains are charged, it may be anticipated that there will be little or no separation of the two components.

With such shearing flows at relative velocities of $> 5$ km s$^{-1}$ it is safe to predict the appearance of considerable turbulence and the associated increase in line width such as is observed. It is also likely that the classical hydrodynamic instabilities may
occur and indeed it is tempting to associate the ‘bay’ region with an instability of the Kelvin-Helmholtz type. (See for example elementary texts such as Lamb, 1945.)

The appearance of the densest dust region, L1642, on the edge of this region would then be consistent with the dust-gas instability associations observed in CrA (Taylor et al. 1982) in which similar relative locations appear for a number of dark cloud components on the HI morphology. The reasons for this disposition have not yet been understood but clearly are related to the mass flow of the various cloud components once the hydrodynamic instability phase sets in.

Since the surface of a cometary globule facing the direction of its motion relative to the i.s.m. will be compressed it is to be expected that an increased gas density will appear in this region. In terms of the present model, the high density ridge along the E side of the object may be the projection of this compressed front on the sky background.

Summary
Detailed maps of the distribution of neutral hydrogen and gas flow velocities are presented for the region adjacent to and including L1642. These correlate well with visible nebulosity in this region.

The results have been tentatively interpreted in terms of a cometary globule structure which contains L1642 in what may be a hydrodynamic instability.

Before the model can be finalised, further details of the velocity and mass distribution are needed in addition to a detailed theoretical analysis. It is also vital to establish what, if any, relationship exists between the outer spectral line components and the cloud gas since at these high galactic latitudes such complex spectra are in general not expected.


The Corona Australis Dark Cloud

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Introduction
The Corona Australis cometary globule is a large southern object known to be a region of slow star formation. We have mapped the complex in the 21cm hydrogen line and preliminary results are reported in Llewellyn et al. (1981) and Taylor et al. (1981). The most extensive A, map of the region is given by Rossano (1978) and is based on star counts. Vrba et al. (1981) give selected A, data from photometric observations in the dark cloud region near the western edge of the complex (identified as cloud A by Rossano). The CO morphology has been discussed by Loren (1979) with some H2CO observations at 2cm and 2mm. Goss et al. (1980) reported the distribution of the 6 cm H2CO line over part of the cloud. We have extended these 6 cm H2CO observations to cover roughly the area mapped by Loren in 12CO. We also report the first extensive OH observations of the dark cloud, mapping in the 1667 MHz main line and using observations of the 1665 MHz main line and the 1612 MHz and 1720 MHz satellite lines to investigate the environmental conditions within the cloud.

Observational Results
Our HI, H2CO and OH observations were taken with the

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Figure 1. The Corona Australis complex
(a) Contours are proportional to N(HI). Shaded areas are minima. Dots indicate the boundary of the region for which A, > 0.4 mag (background level).
(b) Visual extinction A, (from Rossano (1978) ) contours are shown for extinctions of 0.4, 0.7, 1.0, 1.5, 2.0, 2.5, 3.0 and 3.5 mag.
Note: Scales are different in (a) and (b).