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DETECTION OF CARBON MONOXIDE IN THE LARGE MAGELLANIC CLOUD

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SUMMARY

CO emission at 2·6 mm has been detected in the region N159 of the Large Magellanic Cloud, using the 3·9-m Anglo-Australian Telescope. The molecular cloud observed is comparable in properties with those of large clouds in our Galaxy.

Millimetre wave observations have been made of the Large Magellanic Cloud (LMC) at the CO (J = 1–0) wavelength of 2·6 mm, using the Anglo-Australian Telescope (AAT) at Siding Spring Observatory, NSW. Of the four regions investigated in these preliminary observations CO emission was positively identified in one, N159.

With its 3·9-m aperture, the AAT provides a diffraction-limited beam of 3′·8 arc at 2·6 mm, and an overall beam efficiency of about 30 per cent at the coudé focus. A hot electron bolometer-mixer receiver was used (Phillips & Jefferts 1973) giving a noise temperature of 500 K. Frequency profiles were obtained by stepping the single channel (1 MHz wide) of the receiver by means of a frequency-agile local oscillator locked to a synthesizer controlled by the AAT instrumentation computer. Frequency scans were taken in pairs consisting of one 'on' source and one 'off' source. The scan pair was then repeated with a $\lambda/4$ change in position of the secondary mirror, in an attempt to eliminate a sine wave ripple in the baseline due to the formation of standing waves in the coudé optical path arising from local oscillator leakage. To some extent this ripple remained in spite of this subtraction procedure which was repeated many times. The system was calibrated by scanning the Moon (Linsky 1973) while 'sky-dipping' to determine atmospheric attenuation and by hot- and cold-load techniques (Penzias & Burrus 1973). As a check on this calibration, the CO source in the Orion Nebula was observed on several occasions, appropriate beam-dilution effects being taken into account.

The regions observed were 30 Doradus, N159 (Henize 1956), Hodge 47 and 52 (Hodge 1972), selected as representative of H II and obscuration regions. CO was positively identified in N159 only, which is an emission nebula of $\approx$ 4′·5 diameter (Henize 1956) and also a strong continuum radio source with a flux density of 1·93 Jy at 6 cm (McGee & Newton 1972). Fig. 1 shows the summation of data taken on N159 (RA $05^{h} 40^{m} 24^{s}$, Dec. 69° 46′·0, 1950·0) during two observing periods in 1975 August and September. Data points were taken at

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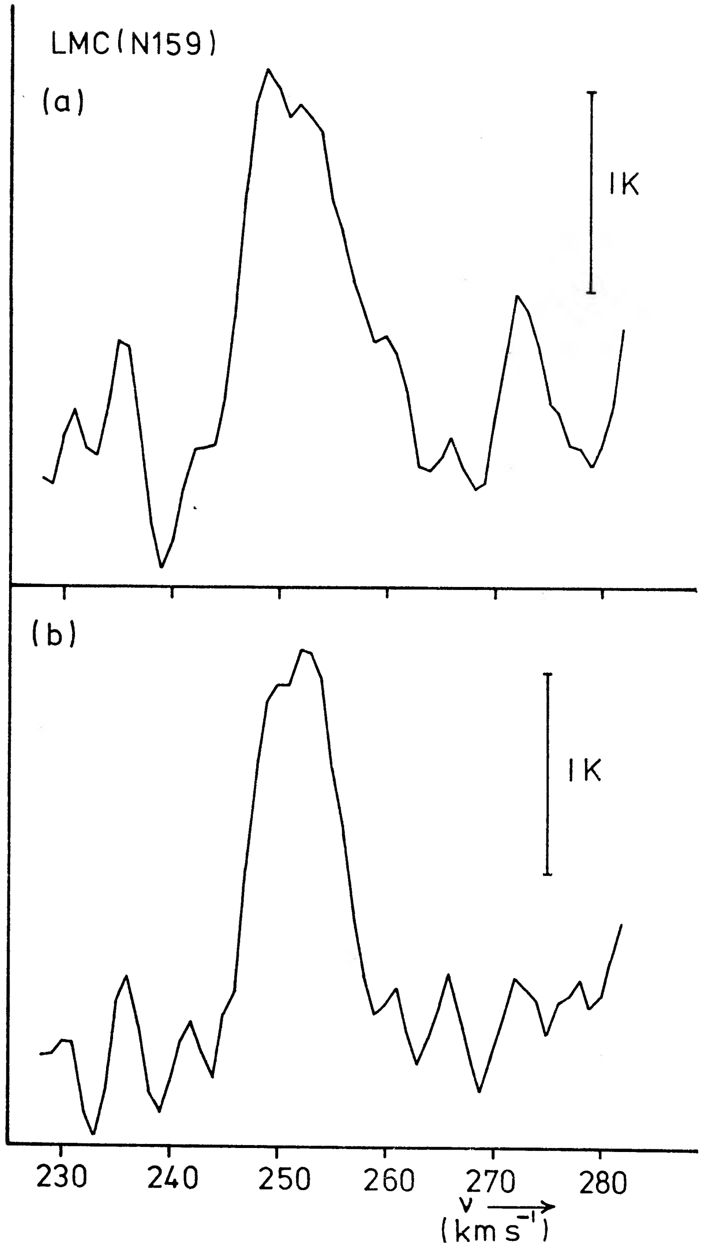

FIG. 1. (*a*) *CO emission at the position of N159. The feature is centred at a heliocentric radial velocity of* 251 *km* s^{-1} *and has a width of* 9 *km* s^{-1}*. The data have been smoothed twice, using a* 33:33:33 *smoothing routine to give a frequency resolution comparable to the system bandwidth. The signal amplitude is in units of corrected antenna temperature* T_A**.* (*b*) *The same data as in* (*a*)*, but with a sinusoidal baseline removed. The period of the sine wave was dictated by the standing waves in the optical path, and the amplitude and phase were determined by fitting to the data points outside the range* 242–266 *km* s^{-1}.

velocity intervals of 1 km s^{-1}, with a total integration time of 192 s at each point, the overall velocity range covered being about 60 km s^{-1}. The signal amplitude is 1.7 ± 0.4 K in terms of antenna temperature corrected for atmospheric and telescope losses (T_A*). Unfortunately, the residual baseline ripple mentioned above dominates the noise in the spectrum. The linewidth of the observed feature is 9 km s^{-1} centred at a heliocentric radial velocity of 251 km s^{-1} which corresponds to 235 km s^{-1} with respect to the local standard of rest.

A 2σ limit $T_A^* = 1{\cdot}3$ K can be placed on the corrected antenna temperature for 30 Doradus and $T_A^* = 2.5$ K for Hodge 47 and 52.

A preliminary comparison of the CO data can be made with the recombination line data of McGee, Newton & Brooks (1974), who found the radial velocity of N159 to be 255 km s^{-1} and the H109α line width to be 30 km s^{-1}. The difference in radial velocities is small and typical of differences between galactic H II regions and the corresponding molecular clouds. Also, as for galactic H II regions, the recombination line is broader than the molecular line, since the former width is determined by the distribution of electron velocities within the ionized regions, whereas the latter is thought to be due to large-scale motion of the cold gas. The CO velocity is consistent with the H I velocity for that part of LMC (McGee & Milton 1966a) and the position is coincident with that for their H I concentration L48 (McGee & Milton 1966b).

We note that the beam width of $3'{\cdot}8$ corresponds to 58 pc at the LMC distance of about 52 kpc. This implies that the antenna temperature of $1{\cdot}7$ K is probably due to a large molecular cloud. If we assume that the gas kinetic temperature is of the order of 10 K and that the CO is thermalized and opaque, as is typically the case for Galactic clouds, it is found that the N159 molecular cloud would have a diameter of 24 pc. This is a size typical of the large molecular clouds of the Galaxy. Alternatively the emission could be due to several smaller clouds covering the same fraction of the beam. It is possible, of course, that the CO is not thermalized and opaque, but studies of the CO ($J = 2-1$) line and the isotopic variants will clarify this.

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