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A New Search for HI in the Southern Coalsack

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Abstract

Since neutral hydrogen in dust clouds can often be detected from narrow self-absorption dips, two 21 cm profiles with a velocity resolution of 0·2 km s^{-1} have been obtained in the direction of the Southern Coalsack, in the hope of finding such a self-absorption dip. No neutral hydrogen could be detected. It is likely that most of the hydrogen in the Coalsack is molecular.

The Southern Coalsack is a large dust complex which covers about 20 square degrees of the sky and is geometrically centred at $l = 303°$, $b = 0°$. Rodgers (1960) found a mean photometric distance for the Coalsack of 170 pc and a mean photographic extinction of $1^m{\cdot}45$, though the extinction over small areas is highly variable. Sinclair and Brooks (1972) have found formaldehyde absorption near $l = 301°$, $b = -1°$ in the Coalsack with a velocity* of $-6{\cdot}5$ km s^{-1} but have failed to find any evidence of absorption near $l = 303°$, $b = 1°{\cdot}5$. The neutral hydrogen distribution in this direction is complex since the Coalsack is located in the galactic plane in the direction of the Sagittarius and Carina spiral features. Previous attempts to find neutral hydrogen in the Coalsack by C. S. Gum (personal communication), using the survey data of Kerr *et al.* (1959), and by Kerr and Garzoli (1968) failed to detect significant emission by gas in the dust cloud. Knapp (1972) has subsequently shown that, if high velocity resolution is used, the HI in dust clouds can often be detected by the typically narrow (~ a few km s^{-1} wide) self-absorption dips due to cool hydrogen in these clouds. Thus a set of narrow-band observations was made in the Coalsack to see if any narrow self-absorption dips could be detected in the profiles.

Hydrogen 21 cm line observations were made at two heavily obscured positions in the Coalsack, $l = 303°$, $b = 0°$ and $l = 304°$, $b = 0°$. The observations were made in 1970 using the 64 m (210 ft) telescope of the Australian National Radio Astronomy Observatory at Parkes, N.S.W., which has a beamwidth of 14 min arc at 21 cm wavelength and a beam efficiency of about 0·8. The multichannel receiver described by Batchelor *et al.* (1969) was used with a channel bandwidth of 1 kHz (0·2 km s^{-1}) and a total bandwidth of 61 kHz (12·2 km s^{-1}), in a frequency-switched mode. The velocity range $-21{\cdot}8 \leqslant v \leqslant +20{\cdot}8$ km s^{-1} was observed at each position. To cover this velocity range, it was necessary to make four successive sets of observations with the central receiver channel set at nominal radial velocities of -15, -5, $+5$ and $+15$ km s^{-1}. At velocities where end channels of observations overlapped, the intensities were simply averaged. Integration times were 4 min at $l = 303°$ and 2 min at $l = 304°$.

* All radial velocities are corrected to the local standard of rest, using a solar motion of $+20$ km s^{-1} toward $\alpha = 18^h$, $\delta = +30°$ (1900·0).

Fig. 1 shows the observed narrow-band profiles. No obvious self-absorption dip is present, and the complexity of the profile in this region makes it difficult to identify any particular feature with the Coalsack. The relatively high antenna temperatures near -20 and $+20$ km s^{-1} are due to the influence of the main Sagittarius and Carina spiral arm peaks. The pronounced dip near -9 km s^{-1} in the $l = 304°$ profile may simply be due to the presence of several distinct features in the profile, as the hydrogen distribution is so complex in this direction. We have no clear indication that self-absorption has contributed to this dip. However, since the formaldehyde results of

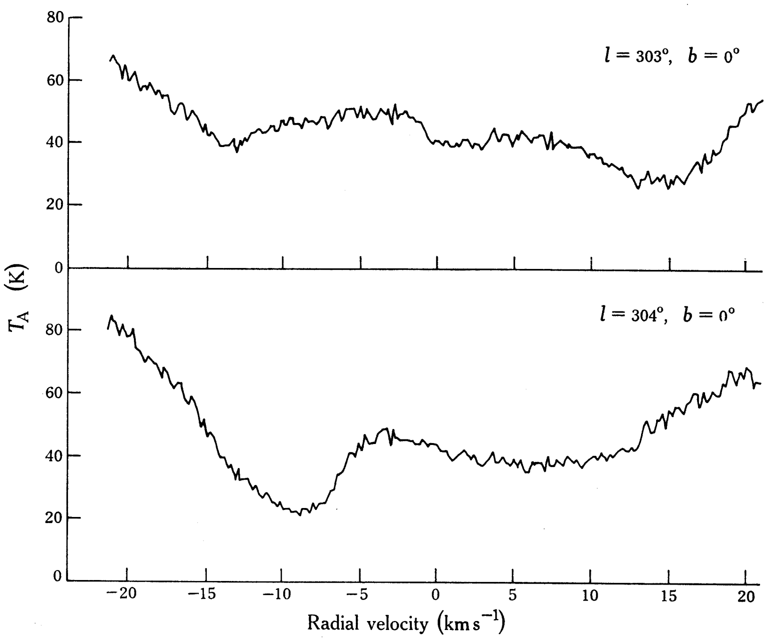

Fig. 1. Partial profiles in units of antenna temperature T_A for two points near the centre of the Southern Coalsack; the velocity resolution is 0·2 km s^{-1}.

Sinclair and Brooks (1972) show absorption at a velocity of $-6 \cdot 5$ km s^{-1}, within the velocity range of the 21 cm dip, hydrogen self-absorption at that velocity could be a contributor to the decrease of intensity. The dip is much too broad to be attributable to self-absorption alone. We have considered whether the steeper side of the dip might be imposed by self-absorption, but an equivalent Gaussian would have a dispersion of $\sim 1 \cdot 6$ km s^{-1}, corresponding to a kinetic temperature of about 300 K, which is too high.

It is likely that the hydrogen in the Coalsack is mainly molecular. Spitzer *et al.* (1973) have shown that stars with $E(B-V) > 0 \cdot 10$ tend to have strong H_2 absorption lines while unreddened stars generally do not have such lines. Their results tentatively support theoretical treatments such as that of Hollenbach *et al.* (1971), which suggest that denser, more opaque clouds with optical absorption $A_v > 1$ should contain substantial amounts of molecular hydrogen. For the Coalsack, the model of Hollenbach *et al.* predicts a column density $N(H_2) \sim 8 \times 10^{20}$ cm^{-2}. The predominance of molecular hydrogen is supported by the detection of formaldehyde by Sinclair and Brooks (1972).

Neutral hydrogen has not been seen at the two points observed at high resolution, but, if atomic hydrogen is present in the Coalsack, its spin temperature and density probably vary throughout the cloud since the optical extinction in the cloud is variable. The ratio $N(H_2)/N(HI)$ may also vary in the cloud. A more extensive observing program in which identical points in the Coalsack are observed in the 21 cm line and a molecular line such as formaldehyde would be advantageous.

Acknowledgments

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