The supernova of AD 1437. The features and the distribution of HII regions. The remnants are within ±200 pc of the galactic plane with a distance from the Sun shows that the majority of the supernova remnant with an object of known distance. In this note we wish to remark on the galactic distribution of supernova remnants and the possible association of these objects with pulsars and X-ray sources.

The distribution of supernova remnants projected on the galactic plane shows a tendency to delineate large-scale features similar to the features found in the distribution of HI emission, OH emission sources and absorption features and the distribution of HII regions. The distance from the galactic plane, z, plotted against distance from the Sun shows that the majority of the supernova remnants are within ±200 pc of the galactic plane with a half-density thickness of about 80 pc; the latter is comparable with the thickness of the neutral hydrogen layer and close to the dispersion in the z-components of OB stars and cepheids, both extreme population I objects. The fairly uniform distribution with z over distances of up to 11 kpc increases our confidence in the distances derived for these objects.

The positions of all the presently known pulsars, 41 in all, were compared with the positions of supernova remnants. With the exception of NP 0532 and PSR 0833-45, which have been previously identified with Sco X-1, the non-thermal radio source Kesteven 17 is inside the error circle although the X-ray source position is closer to the nebula RCG 74, a strong thermal radio source.

The X-ray source position given here is the one quoted by Webber. There is no error given but a previously published position gave an error of ±1°. CTB 37 is within 0.23 of Webber's position. The radio source consists of two non-thermal sources, most probably associated. It has been proposed as the remnant of the supernova of AD 1437.

The position given here is the centroid of this double source.

The position of this X-ray source has been established to a relatively high accuracy and lies within the non-thermal radio source suggested here as an identification.

### Table I

<table>
<thead>
<tr>
<th>No.</th>
<th>X-ray Source</th>
<th>Position (1950)</th>
<th>Error radius</th>
<th>Radio source</th>
<th>Position (1950)</th>
<th>1 GHz radio flux (f.u.)</th>
<th>Spectral index</th>
<th>Angular size (arc)</th>
<th>Distance (kpc)</th>
<th>Surface brightness (W m⁻² Hz⁻¹ ster⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Cep X-1 #</td>
<td>00 18 +66</td>
<td>0.9°</td>
<td>A3</td>
<td>15 22 28 +63 5.9</td>
<td>58 -0.74 6.0 ± 7.0</td>
<td>5.0</td>
<td>1.64 x 10⁻¹⁰</td>
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<tr>
<td>2</td>
<td>Tau X-1 #</td>
<td>05 30 +22 06</td>
<td>1.5°</td>
<td>A3</td>
<td>25 31 51 +58 32.8</td>
<td>3000 -0.72 4.0 ± 3.8</td>
<td>3.4</td>
<td>9.45 x 10⁻¹⁰</td>
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</tr>
<tr>
<td>3</td>
<td>Cas X-1 #</td>
<td>13 08.8 -62.0</td>
<td>1.5°</td>
<td>A3</td>
<td>13 02 39 -62 26.7</td>
<td>15 -0.5 5.2 ± 6.1</td>
<td>7.2</td>
<td>2.3 x 10⁻¹⁰</td>
<td></td>
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</tr>
<tr>
<td>4</td>
<td>Cas X-2 #</td>
<td>15 42 -57.3</td>
<td>2.5°</td>
<td>A4</td>
<td>15 46 26 -56 02.8</td>
<td>145 -0.24 11 ± 8.6</td>
<td>3.2</td>
<td>1.84 x 10⁻¹⁰</td>
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</tr>
<tr>
<td>5</td>
<td>Not X-2</td>
<td>17 12 -38.4</td>
<td>1°</td>
<td>A4</td>
<td>17 11 06 -38 20.9</td>
<td>140 -0.5 28 ± 10</td>
<td>2.4</td>
<td>5.95 x 10⁻¹⁰</td>
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</tr>
<tr>
<td>6</td>
<td>Sco X-2, #</td>
<td>17 58.6 -25 00</td>
<td>15°</td>
<td>A4</td>
<td>17 58 44 -24 54</td>
<td>38 -0.3 12 ± 18</td>
<td>3.4</td>
<td>2.06 x 10⁻⁰⁶</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>GX 5-1 #</td>
<td>17 56.6 -25 00</td>
<td>15°</td>
<td>A4</td>
<td>17 58 44 -24 54</td>
<td>38 -0.3 12 ± 18</td>
<td>3.4</td>
<td>2.06 x 10⁻⁰⁶</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*previously identified with supernova remnants.

#previously identified with WX Cen at a = 13°09'00", b = -63°08' on the basis that this variable star has some of the spectral features observed in the blue object identified with Sco X-1. The non-thermal radio source Kesteven 17 is inside the error circle although the X-ray source position is closer to the nebula RCG 74, a strong thermal radio source.

#fairly intense source 1°7 away from the X-ray source position. The high surface brightness of this source is to be noted suggesting that this object is comparatively young.

The X-ray source position given here is the one quoted by Webber. There is no error given but a previously published position gave an error of ±1°. CTB 37 is within 0.23 of Webber's position. The radio source consists of two non-thermal sources, most probably associated. It has been proposed as the remnant of the supernova of AD 1437.

#The position given here is the centroid of this double source.

The position of this X-ray source has been established to a relatively high accuracy and lies within the non-thermal radio source suggested here as an identification.

**Measurements of OH in Sagittarius A and B2**

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Division of Radiophysics, CSIRO, Sydney

We have measured the absorption spectra of the two principal lines of O¹⁸ H at frequencies 1637 and 1639 MHz approximately in the directions of the sources Sgr A and Sgr B2. The use of 64 x 100 kHz filters enabled us to observe both lines simultaneously. The equipment and methods of observation and reduction are discussed by Gardner, McGee, and Sinclair.

 Earlier detection of the O¹⁸ H line at 1639 MHz was reviewed by Robinson. More recently Wilson and Barrett observed the two lines for the broad absorption in Sgr A at a radial velocity of +40 km/s.

The intensities of the absorption lines are relatively low but by effectively integrating for approximately 4h on each source the rms noise fluctuations were reduced to ±0.03 K. Two sample sets of profiles are given here. Figure 1 is an example showing the 1637 MHz line of O¹⁸ H in the direction of Sagittarius A. The corresponding 1665 MHz line of O¹⁸ H, observed previously with 37 kHz radio
filters, is superimposed. Figure 2 illustrates the 1639 MHz line of O\textsuperscript{18}H and the 1667 MHz line in the direction of Sgr B2.

Two prominent features appear in each source; in Sgr A they are at +40 and —130 km/s and in Sgr B2 they are at +60 and —90 km/s. The corresponding absorption temperatures and corrected half-widths are given in Table I.

We have used the absorption feature in Sgr A at the well-established radial velocity of +40 km/s to fit the 1639 MHz profile to the 1667 MHz profile and obtain a more accurate estimate of the rest frequencies of the O\textsuperscript{18}H lines. For the 1639 MHz line we find

\[ v_0 = 1639.47 \pm 0.01 \text{ MHz}. \]

The frequency difference between the lines, judged from best fit of the +40 km/s features, is 1.95 ±0.02 MHz, and thus for the 1637 MHz line

\[ v_0 = 1637.52 \pm 0.02 \text{ MHz}. \]

Attention is drawn to the large differences in the half-widths between the O\textsuperscript{18}H and O\textsuperscript{16}H lines. The explanation appears to be that the absorbing O\textsuperscript{16}H clouds possess considerable opacity and that the temperature scale should be converted to an optical depth scale before half-widths are measured. Previous authors, e.g. Robinson et al.,\textsuperscript{4} have pointed out the difficulties in estimating optical depths in the Sagittarius region as a result of the complexity of the continuum background. However, the O\textsuperscript{18}H lines must present a very close approximation to the true line shape since the absorption temperatures are so low. Thus the absorption temperature, \( T_L \), on a feature of an O\textsuperscript{16}H line at the true half-width (e.g. 41.6 km/s in the case of the '1639-1667' +40 km/s) can be read from the profile and this will correspond to an optical depth \( \tau/2 \). The \( T_L \) for the maximum optical depth \( \tau \) is available. Since the excitation temperature, \( T_E \), for OH is quite low (\( \approx 3^\circ \text{K} \)) the simple relation

\[ T_L = T_s (1 - e^{-\tau}) \]

may be used to solve for \( \tau \) by eliminating \( T_s \), the effective source temperature. A value for \( T_s \) may then be calculated and used for the corresponding determination of \( \tau \) for O\textsuperscript{18}H.

We have been able to estimate optical depths and hence O\textsuperscript{18}H/O\textsuperscript{16}H abundance ratios in the cases given in Table I. In view of the much better signal-to-noise ratios the results for the positive velocity features for the 1639-1667 lines are much more reliable in each source. Uniform absorbing clouds of OH are assumed in the calculations.

It is seen that in the positive velocity clouds the abundance ratio O\textsuperscript{18}H/O\textsuperscript{16}H is somewhat higher than the terrestrial value of 1/489. In the case of the —130 km/s 1639 MHz line in Sagittarius A the abundance is extremely low. The weak 1639 MHz absorption could be partly caused by instrumental effects but Rogers and Barrett\textsuperscript{5}...
also report weak absorption in this case. The tendency for the 1637 MHz line to be more intense in the negative velocity features is quite pronounced.

It is now possible, using the optical depths from Table I, to derive several ratios of numbers of OH molecules to HI atoms in the direction of Sagittarius A. The relation

\[
\frac{N_{\text{OH}}}{N_{\text{H}}} = \frac{8\pi k n_0 \Sigma g_i}{h^2 A_{22} g_i} \int_{-\infty}^{\infty} \tau \, d\nu
\]

permits the calculation of \(N_{\text{OH}}\), the number of molecules cm\(^{-2}\), while the well-known relation (c.g.s. units)

\[
N_{\text{H}} = 3.88 \times 10^{14} T_{\text{B}} \int_{-\infty}^{\infty} \tau \, d\nu \text{hydrogen atoms cm}^{-2}
\]

may be used with information derived from Kerr and Vallak.\(^6\) Clark\(^7\) has listed some \(N_{\text{H}}\) values which have also been used here. The ratios \(N_{\text{OH}}/N_{\text{H}}\) are compared in Table II.

We believe that the first three ratios represent the conditions in clouds of gas comparatively close to the galactic nucleus and are typical of those in the OH clouds in this region discussed by McGee.\(^8\) A possible explanation for the extremely low ratio in the zero-velocity feature is that the OH cloud may be localized in some region whereas the hydrogen is known to be spread over the whole distance of 10 kpc.

### Table II

<table>
<thead>
<tr>
<th>Rad. vel. of feature (km/s)</th>
<th>(N_{\text{OH}}/N_{\text{H}})</th>
</tr>
</thead>
<tbody>
<tr>
<td>-130</td>
<td>(7.9 \times 10^{-4})</td>
</tr>
<tr>
<td>222</td>
<td>(4.5 \times 10^{-4})</td>
</tr>
<tr>
<td>+40</td>
<td>(3.2 \times 10^{-4})</td>
</tr>
<tr>
<td>-53</td>
<td>(2.4 \times 10^{-7})</td>
</tr>
<tr>
<td>0</td>
<td>(5.0 \times 10^{-7})</td>
</tr>
</tbody>
</table>


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**OH Emission from Protostars**

I. D. JOHNSTON

*School of Physics, University of Sydney*

There is a large body of evidence to suggest that the anomalous OH emission sources—particularly those which are classified as class I sources—are associated with protostars.\(^9\) It is also known, from the theories brought forward over the past four years, that maser action can be caused by quite a variety of non-equilibrium situations. It is argued here that one particular kind of non-equilibrium situation which can plausibly be expected to exist in protostars is very similar to that proposed previously in the electron-pumping model,\(^8\) and that, in this new context, it can mimic most of the observed features of class I sources.

### MODEL OF A PROTOSTAR

Investigations\(^4\) have shown that as a protostar condenses from interstellar medium, it must cool down, reaching densities of \(\sim 10^6\) atoms/cm\(^3\) and temperatures of \(\sim 20^\circ\text{K}\). It is only after this that it becomes opaque to its own radiation and starts to heat up. It is this cool phase we are interested in.

If there is a magnetic field present when the condensation begins, it will be carried with the (weakly ionized) protostellar material and will increase in strength, though not enough to halt the condensation. However it has been suggested by Mestel and Spitzer\(^5\) that, as the density increases, the degree of ionization decreases and the field becomes less strongly tied to the gas. The condensing material will tend in some degree to fall past the magnetic field, which will therefore drift slowly out, and as it does so, it will of course take the ionized component of the gas with it.

The velocity of this drift of field (and ions) relative to the neutral gas may be estimated by balancing the force on the ions due to (i) collisions with the neutral gas, and (ii) the gradient of the magnetic pressure. In the simplified case when field lines are parallel to each other, the velocity of drift (perpendicular to the field lines) is of the order

\[
\nabla \left( B^2/8\pi \right) / n_i m_i v_T \sigma(v_T)
\]

where \(B\) is the magnetic field strength, \(n_i\) and \(m_i\) the density of ions (protons) and neutral (hydrogen) atoms \((\text{proton hydrogen})\) the reduced mass of proton and hydrogen atoms, \(v_T\) the thermal speed of the neutral gas and \(\sigma(v_T)\) the average H-p cross section at this speed.

Consider now a protostar of mass 100 M\(_\odot\) which before collapse had a density of 1 atom/cm\(^3\) and a magnetic field of \(5 \times 10^{-8}\) G. When its density has increased to \(10^7\) cm\(^{-3}\), the field will be \(\sim 0.2\) G; and the gradient of \(B^2\) must be of the order of (and in places much greater than) \(3 \times 10^{-19}\) dyne/cm\(^2\). If further we assume \(n_i \sim 10^{-10}\) cm\(^{-3}\) (Spitzer\(^6\) quotes the most likely values of \(n_i\) between 0.2 and 40 cm\(^{-3}\)) then the velocity of drift of the field relative to the neutral gas is \(\geq 6 \times 10^4\) cm/s—a value which is strictly comparable with the thermal velocity of the neutral atoms (at 20°K). Since in the absence of a magnetic field a protostar collapses uniformly (keeping roughly uniform density throughout), this particular situation will occur at the outer edges of the protostar only when the material is falling perpendicular to the magnetic field.

### MASER ACTION BY OH MOLECULES

Consider now that component of the neutral gas which consists of OH molecules. These interact very strongly with the charged component of the surrounding gas, and therefore, in some parts of the protostar at least, they will experience collisions with ions streaming past them with several times their thermal velocity. It is this non-equilibrium situation which the author has analysed previously\(^8\) (see also the work of Turner\(^3\)) and it is known to lead to a population inversion which will cause maser amplification of the four 18 cm lines.