RADIO STRUCTURE OF THE SOURCES NEAR ON\textsuperscript{2}

Stella Harris

Mullard Radio Astronomy Observatory, Cavendish Laboratory, Madingley Road, Cambridge CB3 0HE

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SUMMARY

The extended H\textsc{ii} regions in the vicinity of the OH maser source ON\textsuperscript{2} have been observed with the Cambridge 5-km telescope at a frequency of 5 GHz and a resolution of 2 arcsec. The northern source, G\textdegree\textasciitilde75\textdegree\textasciitilde84+\textdegree\textasciitilde4, shows compact structure, but the southern source, G\textdegree\textasciitilde75\textasciitilde77+\textdegree\textasciitilde34, is extremely diffuse. There is marginal evidence of extended structure in the compact continuum source which coincides with ON\textsuperscript{2}. The sources have also been observed at 408 and 1407 MHz using the One-Mile telescope.

I. INTRODUCTION

The object ON\textsuperscript{2} was first listed as a Type I OH maser (Elld\text{"{e}}r, R"{o}nn"{a}ng & Winnberg 1969) and was subsequently found to be associated with a very compact radio continuum source (Matthews et al. 1973; Harris 1974). It lies about 45 arcsec north of a region of more extended continuum emission, G\textdegree\textasciitilde75\textasciitilde77+\textdegree\textasciitilde34, and about 4 arcmin south of another such region, G\textdegree\textasciitilde75\textasciitilde84+\textdegree\textasciitilde4, and is thought, on the basis of radial velocity measurements, to be associated with them (Hardebeck & Wilson 1971). The whole complex has been observed by Matthews et al. with the Westerbork Radio Synthesis Telescope at a frequency of 5 GHz and a resolution of 7\textasciitilde2 arcsec; they detected evidence of substructure in the two main continuum sources and suggested that each of these might be interpreted in terms of two gaussian components. Turner et al. (1974), using the NRAO interferometer at 2\textasciitilde7 GHz, have confirmed these results for the northern region, although they question the validity of the interpretation in terms of only two components. They were unable to map the southern region because of confusion from the stronger northern source.

This paper presents 5 GHz observations of the sources using the 5-km telescope (Ryle 1972) at Cambridge, with an angular resolution of 2 arcsec. Observations were also made with the One-Mile telescope at frequencies of 408 and 1407 MHz in order to obtain spectral information.

2. OBSERVATIONS

At 5 GHz the northern and southern regions were observed in 1973 October and November for two 12-hr periods each, providing 32-spacing maps. The synthesized half-power beam area at this declination and frequency is 2\textasciitilde0 \times 3\textasciitilde3 arcsec\textsuperscript{2}, and the rms noise-level is 2\textasciitilde6 \times 10\textasciitilde29 W m\textsuperscript{-2} Hz\textsuperscript{-1} (or 24 K). The two
sources are separated by a distance equal to the radius of the fourth grating-ring so, to reduce confusion, each of them was observed with the telescope beam offset by 7 arcmin away from the other. This had the effect of reducing the response of the source under observation by a factor of 1.5 and that of the other source by a factor of 4. The fourth ring of the northern source thus had a maximum of about $2 \times 10^{-29}$ W m$^{-2}$ Hz$^{-1}$, which was comparable with the rms noise-level of the map of the southern source. The observations were calibrated using the source 3C 147 (Table I).

<table>
<thead>
<tr>
<th>Source</th>
<th>$S_{408}$</th>
<th>$S_{1407}$</th>
<th>$S_{4995}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>3C 48</td>
<td>35.0</td>
<td>15.8</td>
<td>—</td>
</tr>
<tr>
<td>3C 147</td>
<td>—</td>
<td>—</td>
<td>8.2</td>
</tr>
<tr>
<td>3C 295</td>
<td>50.0</td>
<td>22.7</td>
<td>—</td>
</tr>
</tbody>
</table>

Two 12-hr observations with the One-Mile telescope (Elsmore, Kenderdine & Ryle 1966) were made in 1974 February and April, giving four interferometer spacings at 408 and 1407 MHz simultaneously, the half-power beamwidths at these frequencies being $80 \times 132$ and $23 \times 38$ arcsec$^2$, respectively. 3C 295 and 3C 48 (see Table I) were used as calibrators.

3. RESULTS

The observed flux densities of the sources at the three frequencies are listed in Table II. On the 408 MHz map the core of the northern source appears unresolved, while that of the southern source is somewhat broadened. There is evidence of surrounding low-brightness structure, also apparent from single-dish measurements of the region (cf. Matthews et al. 1973) but this has not been included in the estimates of the flux densities, since it would not be detected at shorter wavelengths. At 1407 MHz the peak brightness temperature of G75·77+0·34 (which at 408 MHz was the brighter source) has fallen to little more than half that of G75·84+0·4. Both sources are well resolved by the beam, but there is no indication of structure within their central cores.

At 5 GHz, the northern source (Fig. 1) has two main components with a trough of lower emission measure between them. Each of these components has structure on a finer scale, the western region containing at least two distinct subcomponents. The map of the southern source (Fig. 2), on the other hand, does not
show any well-defined condensations. The peak brightness temperature is only about 270 K, and the structure is so diffuse that it is very difficult to define a meaningful boundary and zero level. As a result of the reduction in level of the confusion from G75·84 + 0·4, the continuum emission associated with the OH maser source ON2 (seen previously only as an unresolved source, Harris 1974) now shows marginal signs of extended structure.

The spectra of G75·84 + 0·4 and G75·77 + 0·34, as determined by high-resolution (≤ 80 arcsec) observations, are shown in Fig. 3(a) and (b), respectively. For G75·84 + 0·4, the areas contained within the contours of the 5 GHz map have been used in the usual way (Terzian 1965) to predict the total thermal spectrum for various values of electron temperature, and in Fig. 3(a) the results are compared with the observational data. The 408 and 1407 MHz points are seen to fit well to an electron temperature of 8000 ± 2000 K. To within 15 per cent (the error inherent in our 5 GHz measurement) the curves are also in agreement with the values obtained at 5 and 10·7 GHz by Matthews et al. (1973). There is, however, a discrepancy with the 2·7 GHz value obtained by Turner et al. (1974) of 2·5 × 10^{-28} W m^{-2} Hz^{-1}. The reason for this is not apparent, but it may be due to problems arising from the incomplete aperture-plane coverage of the NRAO instrument. Adoption of the above range of values for the electron temperature gives a peak emission measure of about 12 × 10^6 pc cm^{-6} for the eastern part of G75·84 + 0·4, and 8 × 10^6 pc cm^{-6} for the western part.

The scatter of the spectral points for G75·84 + 0·34 (Fig. 3(b)) merely reflects the lack of clarity in the outline of the southern source. The spectrum appears to turn over somewhere below 1 GHz but, because the structure at 5 GHz is so
vague, no attempt has been made to fit a thermal spectrum to the points. If the electron temperature is 10000 K, the peak emission measure is about $2 \times 10^6$ pc cm$^{-6}$.

4. DISCUSSION

As mentioned both by Matthews et al. (1973) and Turner et al. (1974), the ON2 complex appears to be a region with stars at various early stages of development. If G75.84+0.4 is divided roughly into two parts along the central trough, the radiation required to ionize the brighter eastern part of the source (which contains about 68 per cent of the flux) could be produced by a ZAMS star of Type O6 (following Panagia 1973) on the assumptions that (i) the source is ionization bounded, and (ii) the distance is 5.5 kpc (Reifenstein et al. 1970). Both conditions should be treated with caution, but if valid they place an upper limit on the spectral type and indicate a formation region of relatively late O/B type stars. On the other
hand it might be that G75.84+0.4 is a shell source ionized by a single central star, in which case this would be of slightly earlier spectral type. There is no evidence of Hα emission on the red print of the Palomar Observatory Sky Survey, indicating substantial obscuration. It would therefore be of great interest to observe the region at infrared wavelengths, especially around the 2-μm region, in an attempt to locate the exciting star (or stars) of the northern source. In the absence of extinction by dust (which is unlikely to contribute more than about 1m at this wavelength),
the $K$-magnitude of an O6-type star at a distance of between 5 and 10 kpc would
lie between $9^{m}$ and $11^{m}$, and would therefore be just about detectable by present
techniques. It would also be interesting to obtain high resolution observations of
the southern region at a different frequency in order to give spectral information
on the compact continuum source associated with ON2.

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