10.7 GHz continuum observations of comet P/Halley
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Summary. A search for continuum emission at 10.7 GHz from Halley's comet has been performed with the Bologna 32 m radiotelescope near the first comet perigee. Owing to the expected low fluxes the beam switching ON-OFF technique was adopted for the observations. Sky background level was determined by subtraction of instrumental and sky temperature long term drifts using a least square fit method. Long time integrations (>3000 s) were obtained for 7 days. The results indicate 2 detections greater than 3σ level with fluxes of \( \sim 14\) mJy.

Key words: comets – radio continuum

1. Introduction

Radio continuum emission has been successfully detected from few comets: Kohoutek 1973 XII (Hobbs et al., 1975), West 1976 VI (Hobbs et al., 1977) and Iras-Araki-Alcock (IAA) 1983d (Altenhoff, 1983). Strong differences in flux density were observed for Kohoutek and West on time scale of a day, suggesting that the continuum may be a transient phenomenon.

Gibson and Hobbs (1981) interpreted the cm wavelength emission of Kohoutek and West in terms of an Icy Grain Halo (IGH) surrounding the nucleus. More recent observations of comet Austin at 6.1 cm (Snyder et al., 1983) established a lower limit to the flux density which is far below the level predicted by the IGH model.

The single dish emission of IAA at 1.3 cm (Altenhoff, 1983) is consistent with a nucleus of 7 km diameter at 200 K. The nearly simultaneous observation of IAA with VLA at 2 cm (Irvine et al., 1984) gives a lower limit for the flux density significantly below the detection at 1.3 cm. The discrepancy may be explained if the emission is due to an extended (100–400 km) component of grains.

The emission of Kohoutek and West corresponds to a monochromatic luminosity order of magnitude larger than that found in Iras-Araki-Alcock. Probably different mechanisms should be invoked for these types of emission.

In the case of the Halley comet the effort of the astronomical community may contribute to better interpret this continuum emission. For this reason a program of observations at 2.8 cm was performed with the new radiotelescope in Bologna. The method of observations and the results are discussed in the following.

2. Instrument and observations

The Bologna antenna is a 32 m Cassegrain operating at the frequencies of 1.6, 5, 10.7 and 22 GHz. The sensitivity is determined by cryogenic FET amplifiers, quality of the antenna surface and pointing accuracy. The search for comet emission was done at 10.7 GHz as a compromise between sensitivity, spectrum of emission and weather conditions at the epoch of observations. At small zenith angles the system temperature is about 100 K (50 MHz bandwidth) and the antenna gain is 0.1 K/Jy. The Half Power Beam Width is \( \sim 5\) degrees, the absolute pointing accuracy, tested on a set of point sources, is about 15"; first sidelobe levels are below 18 dB. The linear response of the instrument to calibration sources with flux lower than 1 Jy was tested (Fig. 1). Fluxes, where necessary, are corrected for zenith angle gain variations.

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The comet nucleus was tracked at sidereal rate by updating the nominal position every 60 s according to the IHW Ephemeris program. Observations were performed with the total power ON-OFF technique with a basic cycle of 10 s ON source and 10 s OFF source (15° Eastward in Azimuth). Every 300 s the signal from a noise source was recorded. Hereafter we call observation cycle the period between two noise calibrations.

In Fig. 2 the ON-OFF antenna response for 3 different sources is shown. The integration time for each acquisition ON or OFF source is 10 s.

Tracking has been done for several hours every day during the period from 6 November to 2 December 1985. Weather conditions and receiver stability limited the available data to 8 days.

3. Data reduction

An integration time of 3000 s was required in order to reach one sigma sensitivity less than 5 mJy. During this time interval the observation cycles may be both affected by fast fluctuations due to interferences and long drifts due to the atmosphere and receiver gain changes. Both effects were removed before the integration.

From the analysis of each observation cycle all signals with an r.m.s. exceeding 5σ level were rejected (1σ is the accepted error level corresponding to the integration time of one cycle). However, the excluded cycles do not exceed the 20% of the total.

We assume that sky temperature long term drifts may be fitted by linear or square functions of time using a least square method.

In each observation cycle there are 15 ON-OFF acquisitions and for each of them we can write the following equations:

\[
T_{\text{sys,ON}} = T_{\text{rec}} + \alpha t + \beta t^2 + T_{\text{source}}
\]

\[
T_{\text{sys,OFF}} = T_{\text{rec}} + \alpha t + \beta t^2
\]

where \( T_{\text{sys}} \) (K) is the system temperature, \( T_{\text{rec}} \) (K) the receiver noise temperature, \( t \) is the time for each acquisition in ON or OFF position, \( \alpha \) and \( \beta \) the coefficients of the linear and square term respectively, \( T_{\text{source}} \) is the source temperature contribution. The least square solution of this equation system is derived for ON and OFF cycles together. It supplies the value of \( T_{\text{source}} \) and its standard error. The square term is used only if the data cannot be fitted with the linear one. We check further that the obtained value of \( T_{\text{source}} \) does not have a residuals systematic drift with time. The line fitted to \( T_{\text{source}} \) has a slope of about \( 10^{-4} \) K s\(^{-1}\).

The antenna temperature for each cycle is averaged with weight of its standard error to obtain the observed antenna temperature for each day. The observation period, the integration time on the source, the measured flux density, the r.m.s. are given in Table 1.

The encounters of Halley with background sources during these periods of observation were checked on the list provided by IHW. Only on 21 and 29 November two sources, OD + 181 and OC + 132, lie in the sidelobe structure. Their fluxes at 10.7 GHz were derived from the quoted 1.4 GHz values assuming a spectral index of \(-0.7\). The resulting possible contribution is 1.5 mJy at maximum.

The time spent OFF-source may be used to check the internal consistency of our data. For each observation cycle we write a system of equations, as the former ones, where the ON and OFF data are formed by the sequence of the real OFF data only. The expected value of \( T_{\text{source}} \) should be of the order of zero, within the error, if OFF contributions during one observing session are always the same. In Table 2 integration time, measured

<table>
<thead>
<tr>
<th>Date (UT)</th>
<th>Int. time (s)</th>
<th>Flux (mJy)</th>
<th>r.m.s. (mJy)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1985</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nov.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7.78 – 7.99</td>
<td>4800</td>
<td>15</td>
<td>3.3</td>
</tr>
<tr>
<td>15.79 – 16.06</td>
<td>4800</td>
<td>8.6</td>
<td>2.5</td>
</tr>
<tr>
<td>21.67 – 21.86</td>
<td>4200</td>
<td>14.3</td>
<td>4.1</td>
</tr>
<tr>
<td>26.82 – 27.06</td>
<td>5250</td>
<td>5.0</td>
<td>2.4</td>
</tr>
<tr>
<td>27.64 – 27.14</td>
<td>1500</td>
<td>-1</td>
<td>6.8</td>
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<tr>
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<td>3.5</td>
<td>1.7</td>
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<tr>
<td>29.67 – 30.04</td>
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<td>13.7</td>
<td>4.5</td>
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<tr>
<td>Dec.</td>
<td></td>
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<tr>
<td>1.59 – 1.75</td>
<td>3500</td>
<td>-1.6</td>
<td>4.1</td>
</tr>
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