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Abstract

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DETECTION IN THE NEBULA NGC 6618 (OMEGA) OF RADIO EMISSION FROM AN EXCITED-HYDROGEN LINE*

(Presented by Academician V. A. Kotelnikov, 5 I 1965)

In the spring–summer of 1964, observations were carried out on the 22-meter radio telescope of the Physics Institute of the USSR Academy of Sciences, the purpose of which was to detect radio emission from the excited-hydrogen line caused by transitions between atomic levels with principal quantum numbers 91 and 90. N. S. Kardashev ([1]) drew attention to the possibility of isolating lines with such an excitation mechanism in HII regions. Subsequent calculations ([2]) made it possible to conclude that, from the standpoint of detecting the effect, the wavelength range 2.5–3 cm is optimal. In this range, when observing the nebula NGC 6618, which is the most convenient object for this purpose, at the frequency of the line of the indicated transition one could expect an increase in the antenna temperature of the 22-meter telescope by 0.5–0.3°. The observations were carried out with the aid of a specially developed null spectral radiometer, the basic principles of whose operation are set forth in ([3]). The observing method consisted of tracking the source with the radio telescope and simultaneously tuning the spectral channel of the radiometer ($\Delta f = 1$ MHz) within a range of ±5 MHz relative to the center of the expected line. For comparison and control, analogous measurements were made with the antenna pointed away from the source NGC 6618 and lowered in elevation until the antenna temperature due to atmospheric emission was restored, and also on the source Taurus-A. In the course of the observations, owing to the use of the null method in the radiometer, equality of the average noise intensities received from the antenna and the equivalent was automatically ensured with high accuracy in the 20 MHz band. Because of this, the influence of tracking inaccuracies on the readings of the output instrument of the spectral channel was substantially reduced, and a number of other instrumental effects were also excluded, the magnitude of which might have been greater than the expected signal. As a result of the measurements carried out in April–May 1964, line emission with an intensity of $0.65 \pm 0.3°$ in antenna temperature was detected, which corresponds to a brightening of the nebula NGC 6618 at the line frequency by $4.2 \pm 1.9\%$.

The line frequency, corrected for the orbital motion of the Earth, the motion of the solar system toward the apex, and also for the radial velocity of the nebula

Figure 1

Figure 1: Figure 1

Figure 2

Figure 2: Figure 2

relative to the Sun, taken to be 20 km/sec, is 8872.5 ± 0.3 MHz, which, within the measurement errors, coincides with the calculated frequency for the 91–90 transitions, equal to 8872.58 MHz. The width of the line at the 0.5 level is about 1 MHz; however, the results obtained do not permit a more definite statement about its structure.

The following facts serve as evidence for the detection of the line in NGC 6618:

1. An increase in antenna temperature at the expected line frequency is evident in each of the 19 records obtained when the radio telescope was pointed at the nebula NGC 6618 (for examples of records, see Fig. 1a).

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* The results of the present work were reported at the International Astronomical Congress in August 1964.

2. Absence of a similar effect when the antenna was pointed away from the nebula (14 records—see Fig. 1) and when tracking the source Taurus A.
3. A decrease in the frequency of the observed brightening by 1 ± 0.3 MHz between

Fig. 1. Examples of records in the direction of NGC 6618 ( ) and of a control record with the antenna pointed away from the source ( ). The vertical lines are frequency marks at intervals of 1 MHz. The large mark is the calculated frequency of the expected line, corrected for the radial velocity on the day of observation. —the result of averaging 7 records in the direction of NGC 6618 and 5 control records for 27-28 IV. The arrow indicates the calculated frequency of the line.

observations in April and in June–July, when additional measurements were carried out. This corresponds to the expected Doppler shift due to the orbital motion of the Earth (Fig. 2).

Fig. 2. Radial velocity of NGC 6618 relative to the Earth. The curve is calculated; the points are experimental data.

The obtained value of the relative brightening in the line agrees very closely with the calculated data ([2]). For the adopted value of the electron density of the nebula, $N_e = 500$ cm^{-3} ([4]), the line intensity in the 3-cm range should amount to 4% of the level of the continuous spectrum. A lower intensity of the observed line would seem natural because of the nonuniform distribution of gas in the nebula; in this case, at the same mean density, the influence of the pressure effect increases, leading to a strong decrease in the line contrast.

In ([5]) it is indicated that in NGC 6618 the gas density falls rapidly with distance from the center of the nebular core. It is also quite possible that there are larger density fluctuations, analogous to what occurs in the Orion Nebula ([6]). From this point of view, the intensity of the line in NGC 6618 at a frequency of 5763 MHz turned out to be substantially greater than could have been expected. The ratio of the line intensity to the intensity of the continuous spectrum, according to the measurements of A. F. and Z. V. Dravskikh and V. A. Kolba-

was * $3.8 \pm 0.5\%$. At the same time, if the estimates adopted in (2) for the effect of pressure are correct, even for a uniform density with $N_e = 500$ cm^{-3} this ratio should be less than 1%.

It should be said, however, that information on the nebula NGC 6618 is still very limited. Up to the present time neither the stars exciting it nor the distance to the nebula are known precisely. Moreover, the data on density obtained from measurements of surface brightness may be regarded as very approximate. Some parameters determining the emission of lines at high excitation levels also require refinement.

Further theoretical and experimental studies over a wide frequency range are needed for a more thorough clarification of the processes of formation and emission of radio lines of excited hydrogen.

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Note: Figure translations are in progress. See original paper for figures.