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van Gorkom, JH; Goss, WM; Shaver, PA

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Letter to the Editor

H I Absorption in the Direction of SS 433

J. H. van Gorkom[1], W. M. Goss[1], and P. A. Shaver[2]

[1] Kapteyn Astronomical Institute, University of Groningen, Postbus 800, 9700 AV Groningen, The Netherlands
[2] European Southern Observatory, c/o CERN, CH-1211 Geneva 23, Switzerland

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Summary

HI absorption has been observed in the direction of the unusual object SS 433 with the Westerbork Synthesis Radio Telescope. The HI data imply a lower limit of 3.7 kpc for the distance of SS 433 and a weak upper limit of 4.7 kpc. This agrees with the lower limit derived by Margon et al. (1979) based on observations of the interstellar NaD lines and is consistent with a physical association of SS 433 with the SNR W50.

Key words: HI absorption – radio sources – supernova remnants.

Introduction

The identification of the compact, time variable radio source 1909 + 048 with an unusual optical object SS 433 was made by Clark and Murdin (1978) and subsequently discussed by Feldman et al. (1978), Ryle et al. (1978). The large redshift spectral features have been described by Margon et al. (1979). Clark and Murdin (1978) suggested that SS 433 may be physically associated with the supernova remnant W50.

The distance of SS 433 must be known in order to establish a physical association with W50 and to determine the physical properties of this very unusual object. An estimate of 1.6 – 3.2 kpc was given by Clark and Murdin (1978) based on interstellar reddening. Margon et al. (1979) derived a lower limit of 3.5 kpc based on high resolution observations of the NaD lines. However it was pointed out by them that the distance could be substantially greater than 3.5 kpc. To refine this limit we have made an HI absorption observation of SS 433 with the Westerbork Synthesis Radio Telescope (WSRT) and the 5120 channel digital line backend.

Observations

1909 + 048 was observed with the WSRT for six hours (hour-angle ± 3 hours) on July 27, 1979. Seventeen interferometers were used with spacings of 36, 72, 180, 216, ..., 188 and 1244 m (the spacing 612 m was not available). The total bandwidth was 625 kHz with 127 frequency points; the resolution was 5.9 kHz or 1.2 km s^{-1}. The calibration procedure has been described by Goss et al. (1979). The system temperature was 90° K.

The HI emission profile in the direction of SS 433 (ℓ = 39°.7, b = −2°.0) was obtained with the Dwingeloo 25 m telescope. The system temperature was 47° K and the total bandwidth 1.25 MHz; with 256 channels and Hanning smoothing the resolution is 9.8 kHz or 2.1 km s^{-1}. The amplitude scale has an uncertainty of ± 15%.

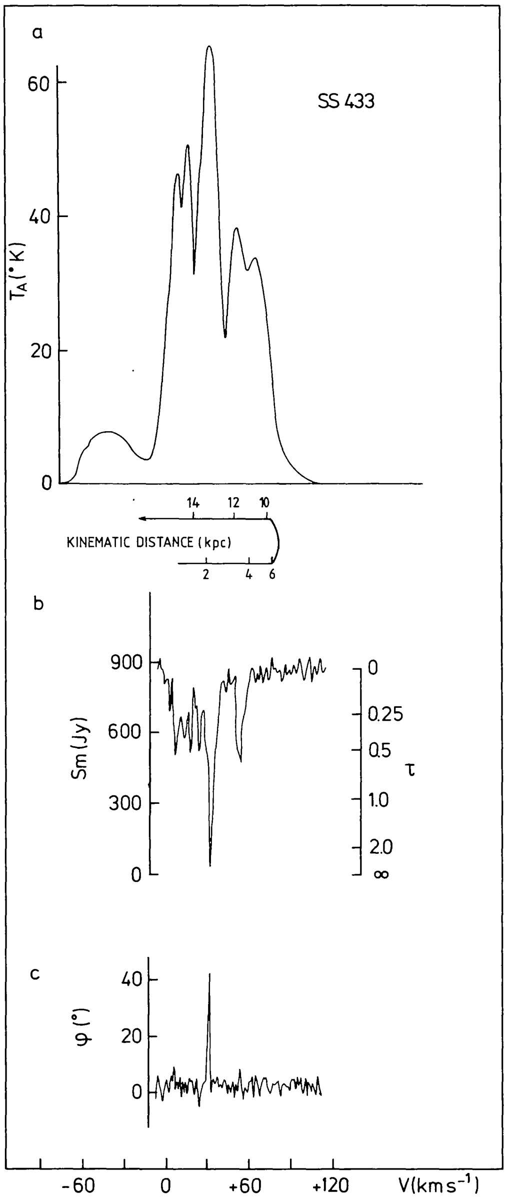

Figure 1. →
The 21-cm spectrum in the direction of SS 433.1 (a) is the emission profile (antenna temperature) obtained with the Dwingeloo 25 m telescope. The velocity resolution is 2.1 km s^{-1}. The amplitude scale has an uncertainty of ± 15%. 1 (b) and 1 (c) are the Westerbork absorption observations: 1 (b) the amplitude, and 1 (c) the phase. The velocity resolution is 1.2 km s^{-1}. The field centre used is the radio position given by Ryle et al. (1978). All velocities are with respect to the local standard of rest. The kinematic distance scale is based on the Schmidt rotation curve. →

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Results

The HI emission profile obtained at Dwingeloo is shown in Fig. 1a. The kinematic distance scale based on the Schmidt rotation curve is also given. The HI emission extends to a velocity of 80 km s^{-1}, corresponding to a distance of 7.7 kpc for the tangential point.

The average absorption spectra formed from 12 baselines over 6 hours is shown in Fig. 1 (b) (amplitude) and 1 (c) phase). The rms noise is ~ 30 mJy in a 1.2 km s^{-1} channel corresponding to $1\ \sigma = 0.034$ in optical depth; the continuum flux density during this observation was 880 ± 30 mJy. The five shortest baselines show pronounced effects of HI emission and were therefore **not** included in the average absorption profile. The presence of these emission effects are obvious from phase and amplitude differences relative to the continuum, both varying with hour angle.

At a velocity of 30 km s^{-1} the optical depth in the HI absorption is large and the (absorbed) continuum signal is weak. Under these conditions the phase is determined by weak HI emission somewhere else in the beam, since the contribution of the continuum source has almost disappeared. The result is a significant phase shift at V = + 30 km s^{-1}, which can be seen at all baselines $\lesssim$ 1080 m and in the average spectrum (Fig. 1c). This HI emission must arise from concentrations less than 25″ arc in size and with a brightness temperature greater than 42° K. (See Caswell et al., 1975 for a description of the calculation of these limits).

At the two longest baselines of 1188 and 1224 m there is no evidence for emission and the optical depth at V = 30 km s^{-1} is 2.0 ± 0.1. The average absorption profile in Fig. 1(b) shows that HI absorption is present over the range 5 to 53 km s^{-1}.

Discussion

The observed HI absorption over a velocity range up to V = 53 km s^{-1} implies a lower limit to the distance of SS 433 of 3.7 kpc, in agreement with the lower limit given by Margon et al. (1979). The problem of determining an upper distance limit from HI absorption measurements is well known (Lockhart and Goss, 1978). In some cases in the galactic plane, reliable upper limits can be set (e.g. Caswell et al., 1975). In the same way we can set a weak upper limit of 4.7 kpc to the distance of SS 433; the corresponding z distance is 160 pc, equal to the scale height of HI clouds (Radhakrishnan and Goss, 1972). The observed emission profile gives in fact further credibility to this upper limit. The rather strong HI emission feature at the highest velocity is the only emission feature at positive velocities that has no corresponding absorption feature.

These distances are consistent with a physical association of SS 433 with the supernova remnant W50; the surface brightness diameter relationship applied to W50 suggest distances in the range of 2.2 kpc (Milne, 1979) to 3.3 kpc (Caswell and Lerche, 1979).

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