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Kinematic Distances of SNRs W44 and 3C 391

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Abstract. We extracted the neutral hydrogen absorption spectra of supernova remnants W44 (G34.7-0.4) and 3C 391 (G31.9+0.0) from the VLA Galactic Plane Survey data. The revised distance of W41 is about 3.3 kpc replacing the previous 3.0 kpc. Further, we confined the distance of G31.9+0.0 to about 7.2 kpc due to its interaction with its surrounding molecular clouds.

Keywords. methods: data analysis, techniques: radial velocities, ISM: supernova remnants

1. Introduction

Distance of supernova remnants (SNRs) is not only a basic parameter of finding their properties such as radius and explosion energy, but also a key factor to research the related high energy phenomena. Recently, the kinematic distances of more than 10 SNRs have been revised by analyzing their H I absorption spectra and ^{13}CO spectra (Tian & Leahy 2011). Here we report our measurement on SNRs W44 and 3C391 which are related with high energy phenomena and interacting with their surrounding environment. Our measurements are based on the assumption of the basic Galactic parameters $V_\odot$ = 220 km s^{-1}, $R_\odot$ = 8.5 kpc.

2. W44

W44 (also named G34.7-0.4, 3C392) has a shell-like radio-continuum morphology (Figure 1.) with a centrally peaked distribution of thermal X-ray surface brightness (Cox *et al.* 1999). It lies in a complex region which is close to several molecular clouds and a giant molecular cloud (GMC) complex (Dame *et al.* 1986).

We have obtained its H I absorption spectrum (Figure 1.) from the VLA Galactic Plane Survey (VGPS) data. This spectrum shows the highest absorption velocity at 50 km s^{-1} much less than the velocity of tangent point in the direction of W44. This gives a lower limit distance of 3.3 kpc for W44. The H I spectra of W44 show H I emission but no associated absorption beyond the velocity of ∼50 km s^{-1}. This constraints W44 at a distance of 3.3 kpc. Caswell *et al.* (1975) found the highest velocity absorption feature of 42 km s^{-1} then concluded that the distance of W44 was 3 kpc ($R_\odot \sim 10$ kpc was adopted) with low velocity resolution data. The VGPS observations provide the strongest evidence to date that the W44 is no further than 3.3 kpc distant; in turn, this supports earlier conclusions that the OH (1720 MHz) maser emission, which peaks at a velocity of 46.9 km s^{-1} (Claussen *et al.* 1999), is physically associated with the W44.

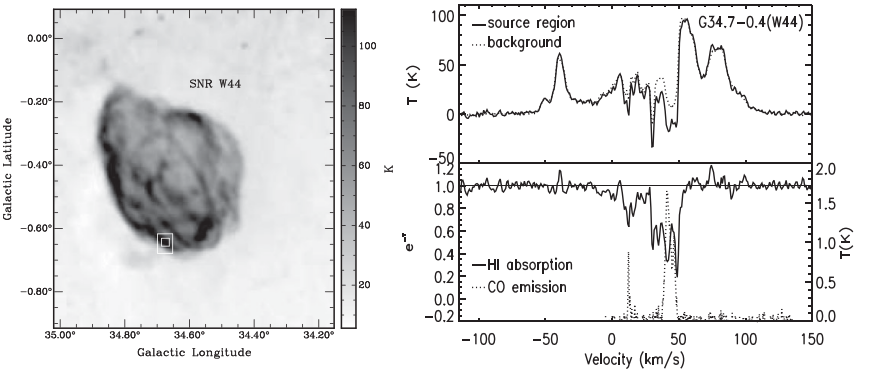

Figure 1. The 1420 MHz continuum image of W44 (left). The H I and CO emission apectra and H I absorption spectrum of W44 (right).

3. 3C 391

3C 391 (also named G31.9+0.0) is a thermal composite remnant, with center-brightened thermal X-ray emission (Rho & Petre 1996). The radio morphology of 3C 391 is a half shell of radius 5′, with another half extend out the open end of the shell which suggests it breakouts into a region of significantly lower density (Renolds & Moffett 1993).

New H I absorption spectrum of 3C 391 reveals the highest absorption velocity at 108 km s^{-1}, i.e. at tangent point, this implies a lower limit distance of ∼7.2 kpc for 3C 391. There is H I emission peak at 70 km s^{-1} but lack of absorption, which hints the H I cloud lies behind the continuum source 3C 391. So we give an upper limit distance of 10.4 kpc.

This conclusion is supported by several H I emission peaks without associated H I absorptions in the velocity from 30 to 50 km s^{-1}. Previous studies showed that this SNR has an interaction with clouds at the tangent point (Wilner *et al.* 1998). We conclude that 3C 391 is most likely at a distance of 7.2 ± 0.3 kpc. The uncertainty of 0.3 kpc is from the Galactic parameter's uncertainty and the measurement errors.

Caswell *et al.* (1971) suggested a distance of 8.5−13.4 kpc for 3C 391 because of the H I absorption velocity at 105 km s^{-1} and the lack of absorption at 35−60 km s^{-1} (for a Galactocentric distance of 10 kpc) by Parkes 21cm line observations.

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