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L-D DEPENDENCE FOR SUPERNOVA REMNANTS

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Abstract. We discussed here the $L-D$ relation (the possible dependence of the radio luminosity on linear diameter) for the supernova remnants (SNRs) in order to see weather determination of SNR distances on the basis of $\Sigma - D$ relation is possible.

1. INTRODUCTION

One way for better understanding of supernova remnants evolution is studying of the surface brightness-to-diameter relation ($\Sigma - D$). The first theoretical $\Sigma - D$ relation was derived by Shklovsky (1960a) in the form

$$\Sigma = AD^{-\beta}. \tag{1}$$

He also proposed the model for determination of SNR distances using this relation (Shklovsky 1960b). Many authors in the next four decades worked to improve theoretical $\Sigma - D$ relation, and also to update empirical relations in view of new observational data. Nevertheless, there exists considerable skepticism about using the $\Sigma - D$ relation in order to determine distances to individual remnants, because the selection effects are severe, especially for the Galactic sample.

Our goal was to examine the utilization of the $\Sigma - D$ relation in order to estimate the distances to shell type SNRs discussing the possible dependence of the radio luminosity on the linear diameter ($L - D$ dependence).

Using appropriate definitions for flux density and angular diameter the following equation can be obtained:

$$\Sigma \propto L_\nu D^{-2}, \tag{2}$$

where L_ν is the radio luminosity of a remnant per unit frequency.

In the case of severe scattering in radio luminosity for a given diameter, the $L - D$ dependence can not be claimed to exist; therefore we can not determine the SNR distances on the basis of the $\Sigma - D$ relation. If the $L - D$ relation is obtained then the $\Sigma - D$ relation could be used for estimation of SNR distances.

2. ANALYSIS AND RESULTS

We searched the literature to find recent and accurate distances to as many shell remnants as possible. We discussed the $L-D$ dependence for galactic and extragalactic SNRs. For the extragalactic SNRs the problem of selection effects is not severe as for galactic SNRs. However, the extragalactic samples tend to be small due to sensitivity limitations of radio instruments.

The surface brightness and flux densities used in this analysis are referred to 1 GHz.

2. 1. $L-D$ DEPENDENCE FOR GALACTIC SNRS

The surface brightness and angular diameters are taken from Green's catalog (2001 version). We do not find any significant correlation between luminosity and linear diameter for galactic shell type remnants (Fig. 1).

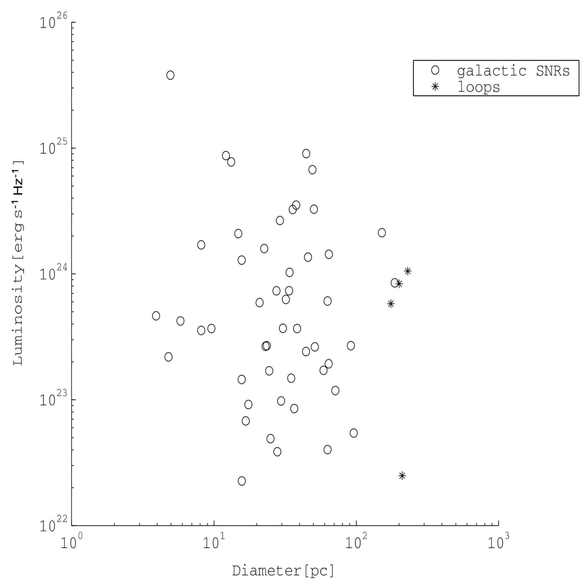

Figure 1: The $L-D$ diagram for the Galactic shell SNRs at 1 GHz.

2. 2. $L-D$ DEPENDENCE FOR EXTRAGALACTIC SNRS

Our extragalactic sample is consisting of 138 SNRs from the following nearby galaxies: M31 (30), M33 (51), Large Magellanic Cloud (LMC – 30), Small Magellanic Cloud (SMC – 16), NGC 300 (3), NGC 6946 (2), NGC 7793 (2), NGC 2146 (3), IC 1613 (1) [1] and 11 SNRs from M82 (Huang et al. 1994). As spectral index has not been

[1](M31) Braun & Walterbos 1993; (M33) Gordon et al. 1999; (LMC & SMC) Berkhuijsen 1986; (NGC 300) Pannuti et al. 2000; (NGC 6946) Lacey & Duric 2001; (NGC 7793) Pannuti et al. 2002; (NGC 2146) Tarchi et al. 2000; (IC 1613) Lozinskaya et al. 1998.

determined yet, we used value $\alpha = 0.5$. Since M31 and M33 catalogs do not have radio diameters included, we used diameters obtained from optical observations.

The $L - D$ dependence does not exist for the chosen sample of extragalactic SNRs (Fig. 2). There could be the L–D dependence for shell type extragalactic SNRs but they can not be clearly resolved.

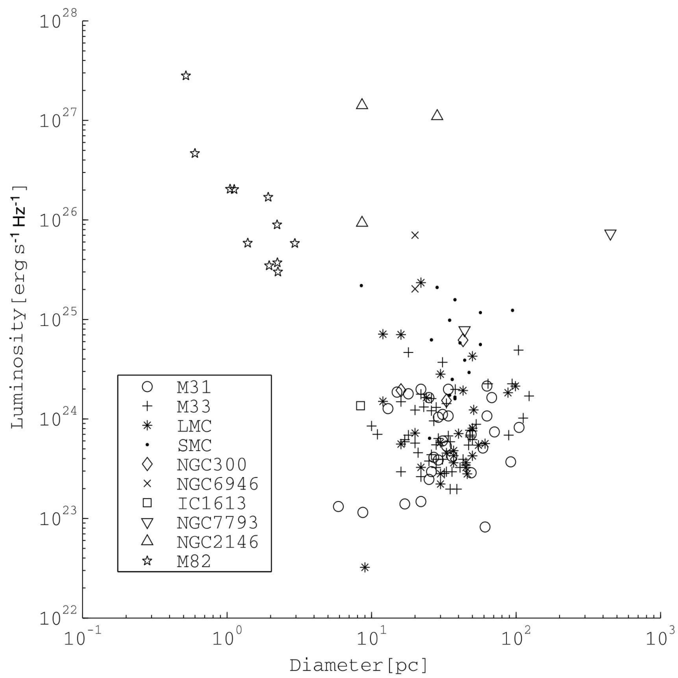

Figure 2: The $L - D$ diagram for the extragalactic SNRs at 1GHz.

Finally we extracted the M82 SNRs from the sample of all available extragalactic remnants. For the SNRs in this starburst galaxy the situation is much clearer because the SNR candidates in M82 are very young, with linear sizes of the order of few parsecs. For this SNRs the steeper $\Sigma - D$ relation is suitable (see Duric & Seaquist(1986)). Huang et al. (1994) identified 50 candidates for SNRs in central region of M82. We chose 11 of them for which spectral indices were available and obtained relation:

$$L_{1\mathrm{GHz}} = 2.71 \times 10^{26} D^{-2.08 \pm 0.40}, \tag{3}$$

with 76% fit quality (Fig. 3).

3. CONCLUSION

We showed that for remnants for which "flatter" $\Sigma - D$ relation with $\beta \approx 2$ (Urošević 2000) is suitable, the $L - D$ dependence does not exist. The $\Sigma - D$ relation can probably be used for determination of SNR distances only for young SNRs ($D < 10$

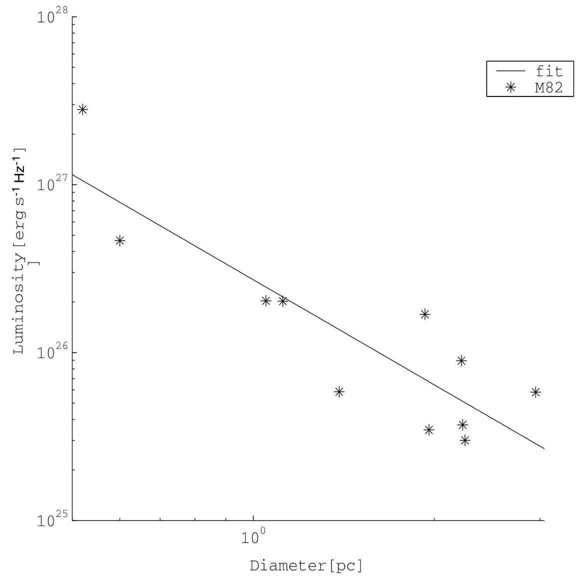

Figure 3: The $L-D$ diagram for 11 SNRs in M82 at 1 GHz.

pc for which the $\Sigma - D$ relation is "steeper" (Urošević 2000)) because the $L-D$ dependence exists for 11 SNRs in M82 starburst galaxy.

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