A Search for Candidates of New Supernova Remnants

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Abstract Some results of searching for new supernova remnants (SNRs) using the most sensitive radio surveys, such as NVSS, WENSS, Miyun are reported. IRAS data and ROSAT data were also used for identifications. Four candidates are presented in this contribution. They are G41.9+0.04, G47.8+2.03, G74.8+0.63, and G93.2+2.63. All of these candidates show shell morphologies, nonthermal spectra, linear polarized emission component, and no strong infrared emission associated. We conclude that they are probably new SNRs

Key words supernova remnant; individual; structure; spectrum

1 Introduction

The recent radio surveys with high sensitivities and space resolution bring us high-quality images covering several parts of the Galactic plane. This provides a new basis to search for new candidates of supernova remnants (SNRs). Four SNR candidates, G41.9+0.04, G47.8+2.03, G74.8+0.63, and G93.2+2.63, identified from the radio surveys including NVSS (Condon et al. 1998), WENSS (Rengelink et al 1997), Miyun (Zhang et al. 1997), Effelsberg 11cm survey (Reich et al. 1988, 1990; Fürst et al. 1990; Duncan et al. 1999), and GB6 (Gregory et al. 1996) are presented in this contribution. The candidates are the results of a more detailed examination of the radio survey data listed above, together with IRAS 60/100 μm infrared images and ROSAT images. The component of polarized emission was also examined for these objects using NVSS 20 cm and Effelsberg 11 cm polarization data.

Morphology, linear polarization, nonthermal spectrum, and no strong infrared emission associated are widly accepted as the criteria to identify new SNRs. The tools to identify new SNRs were completed in recent years with X-ray data as well (Reich, 2002). All the candidates listed above belong to small angular objects. According to the statistical results the observed number of small angular SNRs is much less than that expected by theory. On the other hand, there is a gap in SNR statistical study. One possible explaination is that the small angular SNRs are either very young or far away. In general young SNRs are usually located in a very complex environment. Mixture of thermal and nonthermal emission in such area is a common phenomenon. So to separate the thermal and nonthermal emission would be necessary before calculating the spectral index. Discoveries of small angular SNRs will serve to fill the statistical gap. This is useful on the study of SNR evolution and interstellar medium (ISM) because young SNRs are at an important evolution stage and interacting with their environment.

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Survey data used in this study will be described briefly in section 2 and a part of the results will be given in section 3.

2 The Surveys

Several radio surveys have been used in this searching. The most important one is NVSS (Condon et al. 1998). The NVSS was carried out at 20cm band by NRAO with the VLA D configuration. The synthesis beam of this survey is $45'' \times 45''$. The noise fluctuation of NVSS I map is about 0.45 mJy/beam and about 0.29 mJy/beam in Q and U maps. The largest angular size of D configuration at 20 cm band which can be reasonably well imaged in snapshot observation is about $450''$ (Perley 2000). The shortest base-line of VLA D configuration is 35 m. This allows us to search SNR candidates smaller than $10'$ using the NVSS data without serious missing large scale flux densities. This is also helpful in reducing the effect of very large scale source and any back ground structure. By reducing the confusion, it can distinguish the relatively small angular objects which are near a strong and large object.

WENSS is another important radio survey at a low frequency of 327 MHz. Its synthesis beam is $54'' \times 54'' csc\delta$ which is similar but larger than the NVSS beam. Its map fluctuation of 5σ is about 18 does not match the NVSS well for this searching even taking the SNR spectral property into account. WENNSS covers the sky area of north 30^o which is smaller than the NVSS coverage. The Miyun survey (Zhang et al. 1977) recorded about 34000 radio sources covering the sky area north of 30^o. The data were used for calculations of spectral indices for a member of candidates.

At high frequencies the Effelsberg 1,cm survey (hereafter E11) (Reich et al. 1988, 1990; Fürst et al. 1990; Duncan et al. 1999) and the Green Bank survey at 6 cm band (Gregory et al. 1996) were used to check the spectrum of the candidates found with low frequency surveys. As the beams of E11 and GB6 are rather large and different, the spectral indices obtained with them do not cover exactly the same emission area as that of the NVSS and WENSS. More analysis has to be done before using the spectral information calculated with them.

Since SNR's emission is of nonthermal nature, it is expected that no strong infrared emission associate with it. This was confirmed by observations, especially for the evolved SNRs. Some young SNRs are enclosed by thermal emission because of the shock-heated dust. It is quite complex to analyze the association of SNR and infrared emission. Association with the IRAS 60/100 μm images (Beichmann et al. 1985) with candidates presented in this paper have been checked. The comparison method we used basically follows the method reported by Fürst et al. (Fürst et al. 1987). The main idea is to calculate the ratio of intensities of infrared and radio. This is quite efficient in identifing SNR candidates, at least to separate the thermal objects from the candidates.

3 The New Candidates

Table 1 lists the basic parameters of the four candidates found from this searching. The searching started with examination of the total intensity images in the Galactic plane of $|b| \leq 10^o$ covered by NVSS. Because SNR emission is of synchrotron machnism, linear polarized component is expected to be found. So the NVSS polarization images, Q/U, are checked when some possible candidates were found according to their total intensity morphologies. The E11 polarization information is used when no NVSS polarized data available or in case there is depolarization at the relative low frequency. Finally the ratio, R, between infrared and radio emission were calculated for further identification.

Table 1 The basic parameters of the four candidates obtained from the NVSS images

Name	Position (J2000)	Angular size ($'\times'$)	Peak/integrated intensity(mJy)	Type
G41.9+0.04	19:07:51.0;08:00:59	3×3	50/550	S
G47.8+2.03	19:11:38.9;14:08:42	7×5	6/56	S
G74.8+0.63	20:17:39.1;36:46:07	5×5	137/1460	S
G93.2+2.63	21:13:50.1;52:27:37	4×4	31/260	S

3.1 G41.9+0.04

This object is the smallest one of the four candidates. The NVSS image reveals this object as a well defined ring-like shell structure with the diameter of about $3'$. Fig. 1 gives the NVSS total intensity map (left) and the polarization map (right) images. Both WENSS and Miyun surveys do not cover this sky area because of the low declination of this object. No obvious polarized emission related to the G41.9+0.04 was found either from the NVSS or E11 data. IRAS 60 μm and the E11 data were used to calculate the ratio R following the method of Fürst et al. (1987). They defined a criterion of HII region as R: $500\sim1000$. The R value of G41.9+0.04 is about 100. Although it is lager than the values of most evolved SNRs it is still smaller than 500. This may be common for small angular SNRs, because they are usually not well evolved and may be associated with thermal emission environment, the shock-heated dust (Vessey 1995). This is also potentially an important tool in separating compact SNR candidates from the extragalactic synchrotron population.

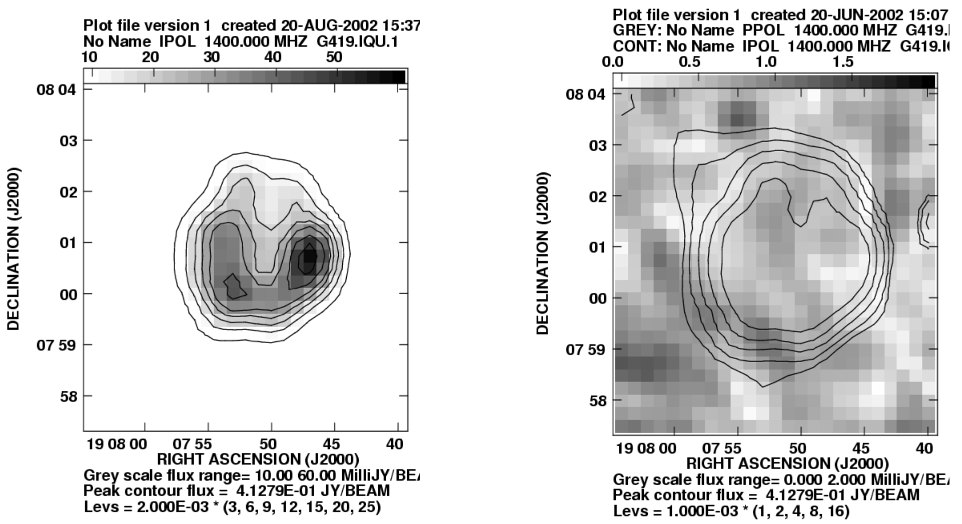

Fig. 1 The total intensity map (left) and polarization map of G41.9+0.04 (right,grey map) obtained from NVSS

3.2 G47.8+2.03

This object is the weakest one of the four candidates. The NVSS image reveals this object as a well defined shell structure. Fig. 2 gives the NVSS total intensity map and the E11 polarization map because there is no polarized NVSS data available for this object. Both WENSS and Miyun surveys do not cover this sky area because of its low declination

Polarization emission from this object is evident according to the E11 polarized data. The morphology and the polarization features suggest G47.8+2.03 is probable a SNR. IRAS $60\,\mu$m and the E11 total intensity data were used to calculate the ratio R. The R value of G47.8+2.03 is about 40. This also confirms that G47.8+2.03 is not a thermal object because $R_{G47.8+2.03}$ is much less than that of a thermal object such as HII region or planetary nebula(PN).

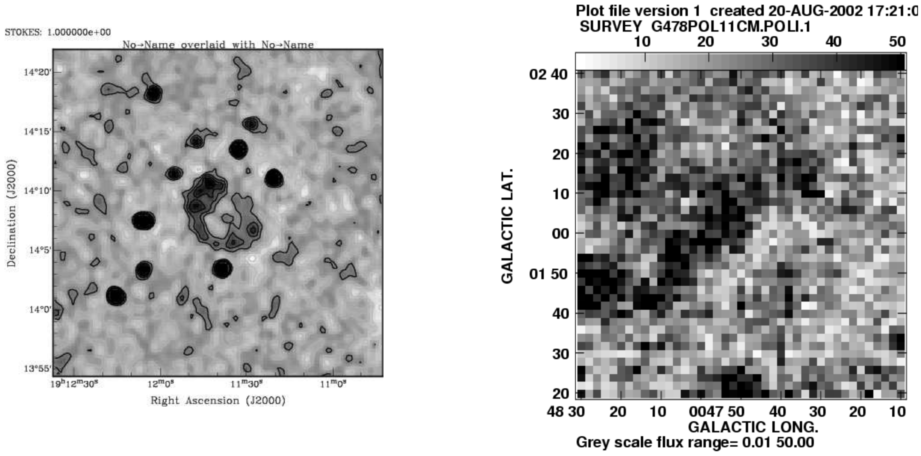

Fig. 2 The total intensity map of G47.8+2.03 (left) obtained from NVSS image and the polarization map obtained from the Effelsberg 11 cm image

3.3 G74.8+0.63

This candidate is resolved clearly by NVSS showing a shell structure of about $5'$ in diameter and it is the strongest one of the four candidates. WENSS image also shows the same morphology with lower resolution of about $54'' \times 90''$. Fig. 3 gives the NVSS images of total intensity (left) and the polarization intensity (right). This object can also be found with Miyun catalog giving the integrated flux density of 1.9 Jy at 232 MHz (Zhang et al. 1997). The basic paramters of this candidate can be found in Table 1. The spectral indices calculated with integrated flux densities at 232, 327, and 1400 MHz are $\alpha_{232}^{1400} = -0.66$ and $\alpha_{327}^{1400} = -0.62$ respectively. Linear polarized emission of G74.8+0.63 was found with the NVSS Q/U maps. Fig. 3 shows the polarized intensity map (right) and the total intensity map (left) respectively. The polarization intensity is about 1.5 mJy level within the G74.8+0.63 region. The morphology, nonthermal spectrum, and the linear polarized component make G74.8+0.63 a very probable SNR.

3.4 G93.2+2.63

This candidate is resolved clearly by NVSS showing a shell structure, which is almost completely circular with a diameter of about $4'$. WENSS image also shows the same morphology in low resolution of about $54'' \times 68''$. Fig. 4 gives the NVSS image. This object can also be found with Miyun catalog giving the integrated flux density of 0.7 Jy at 232 MHz. The spectral indices calculated with integrated flux densities at 232, 327, and 1400 MHz are $\alpha_{232}^{1400} = -0.55$ and $\alpha_{327}^{1400} = -0.32$ respectively. Linear polarized emission of G93.2+2.63 was found with the NVSS Q/U maps. Fig. 4 shows the polarized intensity map (right). The polarization intensity is about 2.0 mJy level within the G93.2+2.63 region. Further polarization observation with high sensitivity at high frequency is needed to confirm the polarized component.

The R value of G93.2+2.63 is about 80. The morphology, spectral index, presence of

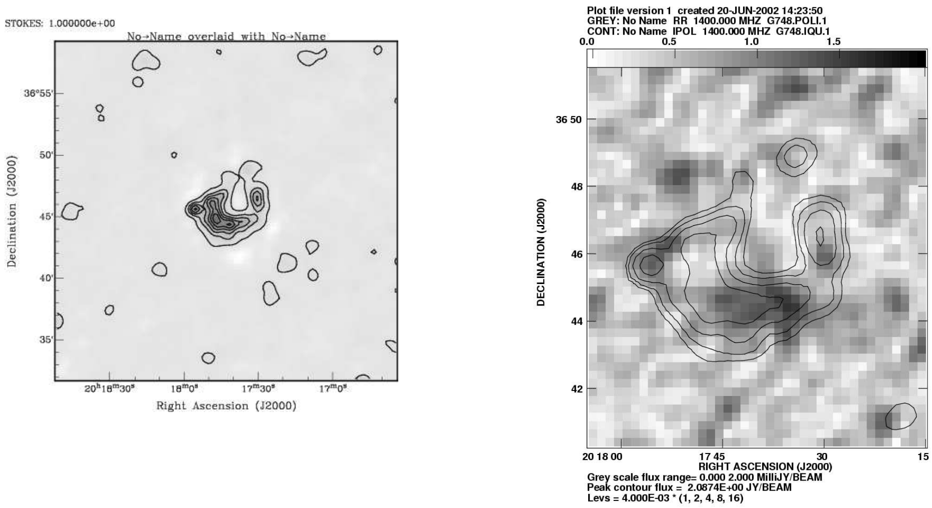

Fig. 3 The total intensity map of G74.8+0.63 (contour) and the polarization intensity (grey map) obtained from NVSS images

linear polarized emission, and no strong infrared emission associated imply that G93.2+2.63 is propably a SNR.

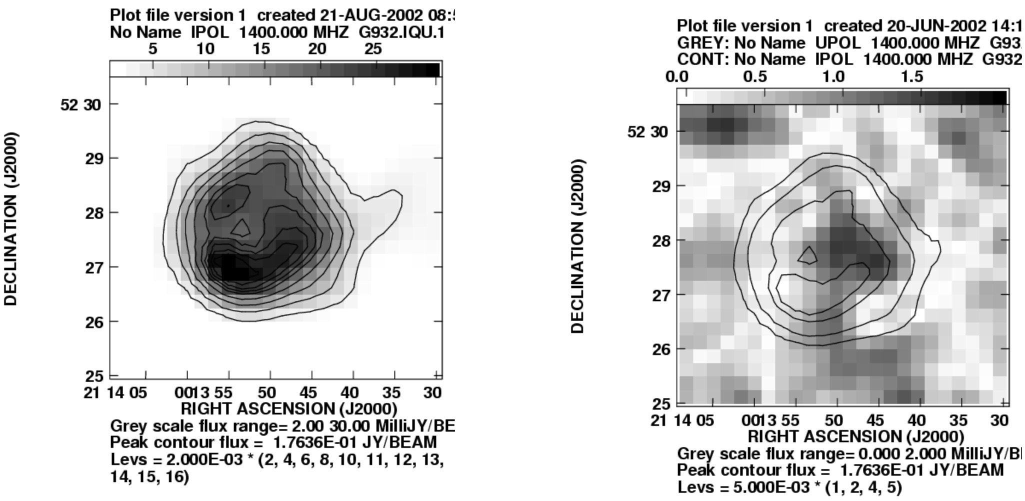

Fig. 4 The total intensity map (left) and the polarization intensity map (right) of G93.2+2.63 obtained from NVSS images

4 Conclusion and Discussion

We conclude that the four candidates are probably new SNRs according to their radio morphologies, radio spectra, linear polarization, and no strong infrared emission associated.

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