Statistics of Galactic Supernova Remnants (continued)

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ABSTRACT

Our statistics on Galactic supernova remnants (SNRs) shows that the electrons temperature ($T$) of hard X-ray and the shock waves traveling velocity ($v$) decreases with ages ($t$) for all-sort remnants. However, the shock waves swept-up mass ($M_{su}$) of ISM increases with the age. Second, the remnant radio fluxes ($S$) at 1 GHz increase slightly with ISM electrons density ($n_0$). At last, the number distributions illustrate that the supernovae (SNe) initial kinetic energy ($E_0$), hydrogen column density ($N_H$), electrons temperature (kT) of hard X-ray, magnetic field ($B$) and the shock waves swept-up mass ($M_{su}$) of ISM mainly peaked at ($1 \sim 10) \times 10^{50}$ ergs, ($1 \sim 10) \times 10^{21}$ cm$^{-2}$, a few KeV, 100 $\mu$G and 10$\sim$100 $M_\odot$, respectively.

Subject headings: methods: statistical (ISM:) supernova remnants

1. Introduction

The statistics on supernova remnants physical parameter have been made by many authors before (eg. Poveda & Woltjer 1968; Clark & Caswell 1976; Lozinskaya 1981; Green 1984; Mills et al. 1984; Allakhverdiyev et al. 1985; Huang & Thaddeus 1985; Duric & Seaquist 1986; Guseinov et al. 2003; Arbutina et al. 2004). Most of them made about the relation between remnants radio surface brightness ($\Sigma$) and their diameter ($D$). Xu et al. (2005) had done a statistics of Galactic SNRs in more details with larger candidate samples. However statistics on other parameters, i.e. the shell swept-up mass ($M_{su}$), electrons temperature ($T$) of hard X-rays, remnants magnetic field ($B$), shock wave traveling velocity ($v$) and electron density ($n_0$) of the interstellar media (ISM) have rarely being done even since.

Here we collected most of Galactic remnants parameters (table 1) mentioned above to make a more detail statistics trying to find more physical connections, which also as a continued work of Xu et al. (2005). We concisely explain how to derive all these remnant parameters in Sect. 2 offer the statistical results in Sect. 3. And at last summarize our conclusion.

2. Parameters of SNRs

Former paper (Xu et al. 2005) has described how some basic physical parameters of Galactic SNRs, i.e. the evolved ages ($t$), kinematic distances ($d$), spectral index ($\alpha$) and the vertical height ($z$) from the galactic plane etc., were estimated. Here more remnants parameters are added up. Many of the radio SNRs own more than one published parameter values. We either chose the most recent estimated ones or adopted an average of the available estimates, or the most commonly used value.

Now let us concisely explain how some basic physical parameters of the supernova remnants are derived, since our statistical work would be based on these.

2.1. Age Estimates
Fig. 1.— Images show the correlations of the physical parameters of both shell-type and other type SNRs in Galaxy. Some of them are labeled with their index ($\beta$) of the best fitting line. Here $Y \propto X^\beta$, $X$ is the x-axis variable, and $Y$ the y-axis one.
There are many measures to obtain the age values ($t$) of remnants (Xu et al. 2005). For example, if a remnant is associated with a pulsar, we can estimate its age by using the neutron star characteristic age obtained from the rotation period of the pulsar ($P$) and the rate of change of period ($\dot{P}$) by $t = P/2\dot{P}$ (Gottshelf et al. 2000). For SNRs with a known radius ($R$) and thermal temperature ($T$) taken from X-ray data, one can obtain the age by $t = 3.8 \times 10^8 R_{pc}(kT)^{-1/2}$ yr (Seward et al. 1995). We can also calculate the SNR age by $t \approx 40000 B^{-1.5} n_0^{-0.5}$ yr, when a remnant has its spectrum showing the usual break at frequency $\nu_0$ due to synchrotron losses in a magnetic field $B$ (Bock et al. 2001).

In our statistics the age ($t$) (and also the Galactic height ($z$)) values are taken from the table in Xu et al. (2005).

2.2. Derived Distances

There are some different methods to derive the distance value ($d$) of supernova remnants (Xu et al. 2005) in Galaxy. These already known distances were derived by the optical proper motion/velocity, HI absorption, association with CO/HI/HII region, HI column density, pulsar parallax and optical velocity, or by various methods (e.g., Green 2004; Xu et al. 2005). Some remnants distance was estimated by the radio surface brightness ($\Sigma$) and linear diameter $D$ relation. Obviously the former methods are somewhat more reliable.

2.3. Initial Explosion Energy

One first method to derive SNe initial energy, for example, by $E = \frac{1}{2} M_{sn} v^2$, here $M_{sn}$ is the swept-up mass of remnant shell expanding into interstellar media (ISM), $v$ is the velocity of shock wave of remnant, the initial explosion energy of SNR G180.0–1.7 is thus obtained (Braun et al. 1989). Sun et al. (1999) calculating their detected ASCA data plus ROSAT data has derived the initial energy of G327.1–1.1 as the fitting result. After knowing the SNR G299.2–2.9 radius ($R$) value, the particle density ($n_0$) and the age ($t$), Slane et al. (1996) get $E_0$ value by $E_0 \approx 340 R^2 n_0 t^{-2} \times 10^{51}$ ergs. Bamba et al. (2001) have got the $E_0$ value by assuming a thin thermal NEI plasma model plus standard Sedov model.

2.4. ISM Density

With emission measure (EM) Landecker et al. (1999) got $EM = \int n_e n_v dV = 4.1 \times 10^{55} (D_{2.5})^2$ cm$^{-3}$ for remnant G93.3+6.9, and then $n_0 = 5.9 \times 10^{-30} (EM)^{1/2} (D_{2.5})^{-3/2} \approx 0.01$ cm$^{-3}$. For SNR G82.2+5.3 Mavromatakis et al. (2004) calculated the hydrogen number density in cm$^{-3}$ is $n_H = 0.657 \times \sqrt{(EM)/D_{1.6}}$. Here $D_{1.6}$ is the distance to the remnant in unit of 1.6 kpc. In particular, for SNR G291.0–0.1 Harrus et al. (1998) estimated the pre-shock electron number density ($n_0$) through integrating the interior radial density variation from the Sedov solution and then equating it to the detected emission measure (EM). And so on.

2.5. Hydrogen Column Density

Methods to derive the hydrogen column density ($N_H$) are usually by fitting the spectrum with different models: power law, thermal bremsstrahlung, black body and thermal hot plasma, etc., Sidoli et al. (2000) found the best fit model for SNR G0.9+0.1 is a power-law with photo index $\Gamma = 1.95$ and got the absorption column density $N_H = 10^{23}$ cm$^{-2}$. For more others, one can see: Craig et al. (1997) for SNR G116.9+0.2 of which $N_H = 7 \times 10^{21}$ cm$^{-2}$, Kothes et al. (2001) for SNR G106.3+2.7 of which $N_H = 6.3 \times 10^{21}$ cm$^{-2}$, Byun et al. (2006) for G89.0+4.7 of which $N_H = (3.5 \pm 0.4) \times 10^{21}$ cm$^{-2}$.

2.6. Electron Temperature

For supernova remnant G352.7–0.1, Kinugasa et al. (1998) found that the spectra are nicely fitted by a non-equilibrium ionization (NEI) model with an electron temperature $kT \sim 2.0$ keV. Lazendic et al. (2005) discover both soft and hard components for SNR G349.7+0.2. The soft one is in ionization equilibrium and has a temperature $T \approx 0.8$ keV, the hard spectral one has a temperature $T \approx 1.4$ keV. But for remnant G49.2–0.7 Koo et al. (2005) fitted the overall spectral shapes reasonably well with a single component equilibrium thermal emission model at temperature of $kT = 0.3 – 0.5$ keV.

2.7. Magnetic Field

The remnants magnetic field ($B$) could be calculated by rotation measure value (RM) plus
Fig. 2.— Diagrams denote the number distributions of the electron density ($n_0$), SNe initial explosion energy ($E_0$), hydrogen column density ($N_H$), electron temperature ($kT$), magnetic field strength ($B$) and the swept-up mass ($M_{su}$) of interstellar medium, respectively.
Galactic electron density distribution. For example, Gaensler et al. (1998) obtain the mean ISM magnetic field along the line of sight in the range $1 - 9 \, \mu G$. The second one is using the Zeeman effect (Brogan et al. 2000). And there are also many some other special measures (Ruiz & May 1986; Sidoli et al. 2000; Gaensler et al. 2002).

2.8 Swept-up ISM Mass

For example, to a middle-age remnant in the uniform interstellar medium and through the analytical Sedov solution, for SNR G 337.2−0.7 Rakowski et al. (2006) got

$$M_{su} = 39.7 \left( \frac{N}{2.0 \times 10^{19} \text{cm}^{-3}} \right)^{1/2} \times \left( \frac{\theta_R}{2.75} \right)^{3/2} \left( \frac{D}{9.6 \text{kpc}} \right)^{5/2} M_\odot$$  \hspace{1cm} (1)

Here, the normalization $N = n_e n_H V / 4 \pi D^2$, $\theta_R$ is the maximum angular radius, $D$ is an upper limit on the remnant distance.

3. Statistical Results

For the image of the swept-up mass and evolving age relation we took samples of 18 shell-type and total 29 SNRs (Fig. 1), the electrons temperature and age relation samples of 30 shell-type and total 43 SNRs, the waves traveling velocity and age relation samples of 41 shell-type and total 59 SNRs, the radio fluxes and age relation samples of 67 shell-type and total 95 SNRs and at last the remnants magnetic field and age one of 15 shell-type and total 27 SNRs.

3.1 SNR Parameters versus Age

Several parameters of the supernova remnant own significant correlation with its evolving age ($t$). For example, the electrons temperature ($T$) of hard X-ray and the shock waves traveling velocity ($v$) decreases with ages for all-sort remnants, with the slope of best fitting line $-0.320$ and $-0.491$, respectively (Fig. 1). However the shell swept-up mass ($M_{su}$) increases with the age, with a fit line slope of about 0.660. Although these plots dispersion is somewhat large, it seems that there are detectable synchrotron emission energy loss of the non-thermal electrons in shock waves, leading to the practically decreases of the hard X-ray electrons temperature and the remnants traveling velocity.

$$M_{su} = 0.171 \times t_{yr}^{0.660\pm0.124} (M_\odot)$$  \hspace{1cm} (2)

$$v = 4.17 \times 10^4 t_{yr}^{-0.491\pm0.085} (\text{km s}^{-1})$$  \hspace{1cm} (3)

$$T = 1.50 \times 10^7 t_{yr}^{-0.320\pm0.063} (\text{K eV})$$  \hspace{1cm} (4)

It shows no obvious meaningful correlation between the SNRs magnetic field ($B$) and evolved age ($t$). This is most likely because that the detected magnetic field denotes those along the line of sight and not mainly the one inside the remnant. Therefore the magnetic field almost remain unchange with time.

The plot also shows an unchangeable radio fluxes of SNRs at 1 GHz (middle-right in Fig. 1). Although there are energy loss of the synchrotron emission of the non-thermal electrons, this has no or not remarkable influence on the remnants radio fluxes.

3.2 Radio Fluxes against ISM Density

For the image of the remnants radio fluxes ($S_{1 GHz}$) and electron density ($n_0$) relation we took samples of 54 shell-type and total 69 SNRs (lower-right in Fig. 1). It tends that when the particle density ($n_0$) of the interstellar medium increases, then to some extent the SNRs radio fluxes would increase slightly but not very remarkably, since the dispersion in the plot is somewhat large.

$$S_{1 GHz} = 19.4 \times n_0^{0.163\pm0.047} (\text{Jy})$$  \hspace{1cm} (5)

It is another evidence that the SNRs (for example, SNR G156.2+5.7) appear enhanced radio emission towards a denser interstellar environment (Xu et al. 2007). When the remnant shock waves interact with a thinner cloud gases the radio radiations will be weaker, and even disappear if lack of surrounding media as the shock waves travel along.

3.3 Number Distributions

We plot the SNRs number distributions of the electron density ($n_0$), SNe initial kinetic energy ($E_0$), hydrogen column density ($N_H$), electron temperature (kT) of hard X-ray, magnetic field ($B$) and the shock waves swept-up mass ($M_{su}$) of ISM in Fig. 2 for shell-type and other type
We found that the supernovae initial explosion energy peaked at about $10^{50} \sim 10^{51}$ ergs, just as the publicly accepted value. The typical value of the hydrogen column density equals about to $(1 \sim 10) \times 10^{21}$ cm$^{-2}$. SNRs magnetic field range from $1 \mu$G to $10^4 \mu$G, mainly concentrates on $\sim 100 \mu$G. Most remnants with the ISM swept-up mass about $10 \sim 100 M_\odot$ were detected. The swept-up mass of an SNR could reach as high as $10^5 M_\odot$.

At last, there are no other rather meaningful correlations among all these SNRs parameters (table 1) could be discovered.

4. Summary

Our statistics on Galactic supernova remnants (SNRs) shows that

1. The hard X-ray electrons temperature and the shock waves traveling velocity decreases with ages for the all-type remnants.

2. The shock waves swept-up mass of ISM increases with the age.

3. Remnants magnetic field and radio fluxes almost remain a constant with time.

4. The remnants radio fluxes at 1 GHz increase with ISM electrons density.

5. The supernova initial energy, hydrogen column density, electron temperature, magnetic field and the shock waves swept-up mass of ISM has a peak-shape distribution.

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Table 1: Some physical parameters of Galactic supernova remnants adopted on our statistics.

| Source Dia./ $\Sigma$/ $N_0$/ $E_0$/ $N_H$/ $kT$/ $B$/ $M_{su}$/ Ref. |
|------------------|------------------|----------------|------------------|------------------|------------------|-----------------|
| G0.0+0.0 7 — 10000 $\geq$ 40 150 1.5 3000? — 05PMB,96KF,98KFG |
| G0.3+0.0 17 100 — $\geq$ 100 67 — 96KF |
| G0.9+0.2 23 10000 — $\geq$ 3.1 113 1.4/5 05BK,06V,89BGL |
| G4.5+6.8 3 5300 0.5 0.4/0.5 — 5-10 06BGC,89SF |
| G0.3+0.0 17 100 — — — — 70 — 96KF |
| G11.2+0.0 10 220 0.7 0.5 40 0.9 $\pm$ 0.1 — 22 06RBH |
| G16.0+0.1 5 10000 0.1 2-5 1? — 02BMP |
| G18.0+0.3 57 $\geq$ 10 600 0.01 $\geq$ 5 1000 99DGR |
| G18.9+1.1 — 0.06 20 $\geq$ 8.3-9.4 $\geq$ 58.1.12 — 04ISH, 97DSC |
| G20.0+0.2 12 — — 20 300? 10? 05KLS, 06CRG |
| G21.5+0.1 17 10000 0.7 $\geq$ 40 0.9 $\pm$ 0.1 — 22 06RBH |
| G24.7+0.6 32 670 0.018? 0.066 — 0.54 — 87BH,89L |
| G27.4+0.0 8 — 16-23 — 97V, 01BUK |
| G28.6+0.1 16 100 0.1 — 2-5 1? 02BMP |
| G31.9+0.0 13 $\leq$ 30 $\geq$ 2-5 0.9 $\pm$ 0.03 — 03HCG,05C |
| G32.1+0.9 64 — 0.05 2.3 0.8 $\pm$ — 97FVVW |
| G32.8+0.1 35 — — — 1450? — 99KFG |
| G33.6+0.2 38 50 — — — 85-180 — 82R |
| G59.7+0.4 25 $\leq$ 9.6 1 200? — 98KFG,05KON,03K |
| G59.7+0.6 17 3700 0.1 2 39.6 2.99 — 5 03HCG,05C |
| G31.9+0.0 13 $\leq$ 30 0.3-1.4 2.7-4.1 0.46-0.79 — 05CSS,03YMR,03K |
| G32.1+0.9 64 — 0.05 2.3 0.8 $\pm$ — 97FVVW |
| G21.5+0.1 17 10000 0.7 $\geq$ 40 0.9 $\pm$ 0.1 — 22 06RBH |
| G24.7+0.6 32 670 0.018? 0.066 — 0.54 3-5 03TR,06KM,05C |
| G27.4+0.0 8 — 16-23 — 97V, 01BUK |
| G28.6+0.1 16 100 0.1 — 2-5 1? 02BMP |
| G29.7+0.3 57 $\geq$ 10 600 0.01 $\geq$ 5 1000 99DGR |
| G31.9+0.0 13 $\leq$ 30 0.3-1.4 2.7-4.1 0.46-0.79 — 05CSS,03YMR,03K |
| G32.1+0.9 64 — 0.05 2.3 0.8 $\pm$ — 97FVVW |
| G32.8+0.1 35 — — — 1450? — 98KFG |
| G33.6+0.2 38 50 — — — 85-180 — 82R |
| G34.7+0.4 25 $\leq$ 9.6 1 200? — 98KFG,05KON,03K |
| G39.7+0.6 17 3700 0.1 2 39.6 2.99 — 5 03HCG,05C |
| G31.9+0.0 13 $\leq$ 30 0.3-1.4 2.7-4.1 0.46-0.79 — 05CSS,03YMR,03K |
| G32.1+0.9 64 — 0.05 2.3 0.8 $\pm$ — 97FVVW |
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| G24.7+0.6 32 670 0.018? 0.066 — 0.54 — 87BH,89L |
| G27.4+0.0 8 — 16-23 — 97V, 01BUK |
| G28.6+0.1 16 100 0.1 — 2-5 1? 02BMP |
| G29.7+0.3 57 $\geq$ 10 600 0.01 $\geq$ 5 1000 99DGR |
| G31.9+0.0 13 $\leq$ 30 0.3-1.4 2.7-4.1 0.46-0.79 — 05CSS,03YMR,03K |
| G32.1+0.9 64 — 0.05 2.3 0.8 $\pm$ — 97FVVW |
| Source | Dia./ pc | T / Kms$^{-1}$ | $N_0$/ cm$^{-3}$ | $E_0$/ ×10$^{51}$ergs | $N_H$/ ×10$^{21}$cm$^{-2}$ | kT/ KeV | B/ µG | $M_{\ast}$/ $M_\odot$ | Ref. |
|--------|---------|----------------|-----------------|----------------|----------------|---------|--------|----------------|------|
| G93.3+0.9 | 15 | ≥3200 | — | 0.39 | 5.7 | 12 | 2.3 | 3.9 | 99LRR.04GAT |
| G93.7−0.2 | 35 | — | 0.01 | — | — | — | 0.5 | — | 02UKB |
| G94.0+1.0 | 37 | 48 | 0.2? | ≥0.27 | 16 | 0.45 | 15 | 55 | 05F |
| G106.3+2.7 | 139 | — | 0.07 | — | 2 | — | — | 40? | 01KUP |
| G109.1−1.0 | 24 | — | 0.25? | 1-10 | 4.5 | 0.9 | — | — | 06SKP.89BGL.04GAT |
| G111.7−2.1 | 5 | 5200 | 1 | 2-3 | 1.8 | 0.5 | 299? | — | 06FPS.80CD.06V.89BGL |
| G114.3+0.3 | 15 | — | 0.03 | — | 2 | — | — | — | 96BBT.98MWT.04GAT |
| G116.5+1.1 | 32 | 70-120 | — | — | 5 | — | — | 05MBX |
| G116.9+0.2 | 16 | 505 | 0.08 | 0.1 | 7 | 0.3 | — | — | 97CHP |
| G119.5+10.2 | 37 | 400 | 0.02-1 | 0.03 | 3.8 | 0.16-1.14 | 2.9 | 13 | 04TDR.04GAT |
| G120.1+1.4 | 5 | 3400? | 0.3 | 1.16 | 6.4 | 2.15 | 16.5 | — | 05WHB.75VK.06V |
| G126.2+1.6 | 91 | 100 | 13.3 | 7 | 8.0 | 0.05? | — | — | 79RKS.5BMX |
| G127.1+0.5 | 76 | 705 | — | — | — | — | — | — | 84GG.04GAT |
| G130.7+3.1 | 6 | 4000 | 1? | — | 1.8-3 | — | 80? | 43 | 06CRG.89BGL.04GAT |
| G132.7+1.3 | 51 | 20 | 0.27 | 0.31 | 3-6.9 | 0.3,1 | — | — | 91RDL.89BGL.04GAT |
| G135.2+5.7 | 64 | — | — | — | 3.5 | — | — | — | 06KGK.07XHS |
| G160.9+2.6 | 38 | 10-100 | — | 1 | 0.3 | — | — | — | 98MWT.06KGK.89BGL |
| G166.0+4.3 | 57 | ≥100 | 100 | — | 2.9 | 0.83 | — | — | 97GB.89BGL |
| G179.0+2.6 | 59 | — | — | — | — | — | 3-4 | — | 89FRK.04GAT |
| G180.0−1.7 | 84 | 100 | 10 | — | — | — | — | — | 96ACJ.89BGL |
| G182.4+3.3 | 44 | 2300 | 0.013 | 0.24 | ≤4 | 5 | 14 | 98KFR |
| G184.6−5.8 | 3 | 300? | — | — | 0.15 | 3 | — | — | 89SRH.06KM.04GAT |
| G189.1+3.0 | 20 | 450? | 100? | — | — | — | 1.2 | 42 | 30 | 05KLS.75VK.89BGL |
| G192.8−1.1 | 59 | — | — | — | — | — | — | — | 85C |
| G205.5+0.5 | 102 | 45 | 0.4 | — | ≤0.8 | — | — | — | 86O.06KGK |
| G206.9+2.3 | 102 | 400 | 0.01? | 0.75 | 1 | 0.14 | — | — | 86L |
| G260.4−3.4 | 35 | 650 | 0.4-1 | — | 2.9-4.7 | 0.3 | — | — | 95BRL.89BGL.04GAT |
| G261.9+10.0 | 44 | — | — | — | 1.0 | 5 | 4 | 100-280 | 05KBL.05IAB |
| G266.2−1.2 | 52 | 15000 | 1 | — | 2.6-4.1 | 4.4/6.5 | — | — | 97DSC |
| G272.2−3.2 | 8 | — | — | — | — | — | — | — | 95DHS |
| G284.3−1.8 | 20 | 16.9? | 10 | — | — | — | — | 1 | 86RM |
| G290.1−0.8 | 28 | — | 1 | 0.8 | 13 | 0.6 | — | — | 02SSH |
| G291.0−0.1 | 41 | — | 0.034 | 0.25? | 37 | 0.8 | — | — | 98HHSb |
| G292.0+1.8 | 17 | 1700 | 1 | 0.18 | — | 0.4 | — | 20 | 05GHW.89BGL |
| G292.2−0.5 | 43 | — | — | 1.0 | 5 | 4 | 100-280 | — | 05GS.05C |
| G296.1−0.5 | 69 | — | 0.8 | 0.23 | 1.0 | 0.2 | — | 250 | 94HM |
| G298.5+10.0 | 44 | — | — | — | 1.0-1.8 | 0.17 | — | — | 98ZPT |
| G298.8−0.3 | 47 | 6500 | 0.2? | 0.2-0.6 | — | — | 1.7 | 100 | 98GMG |
| G299.2−2.9 | 2 | 700 | 0.093 | 0.12 | 0.3 | 0.6 | — | — | 96SVH |
| G308.8−0.1 | 50 | — | — | — | — | — | — | — | 92KMJ |
| G309.2−0.6 | 16 | — | 0.2 | — | 10 | — | 1-9? | 20-170 | 98GGM |
| G312.4−0.4 | 34 | — | 0.8 | 0.6 | — | — | 6 | — | 99CB |
| G315.4−2.3 | 28 | 3500? | 100? | 0.66 | 4.3-7.0 | 1.4 | 10 | — | 03WTK.89BGL.05BYY |
| G315.4−0.3 | 37 | — | — | — | — | — | — | — | 81CMW |
| G318.2+0.1 | — | — | 1? | — | 15 | 5? | — | — | 01BPM |
| G320.4−1.2 | 53 | — | 100 | 1-2 | 9.5 | 1.3 | — | — | 02GAP.06KM.89BGL |
| G321.9−0.3 | 70 | 340 | — | — | — | — | — | — | 02MLC.89SFS |
| Source          | Dia./\(\mathrm{pc}\) | \(T/\mathrm{Km}\) | \(N_0/\mathrm{cm}^{-3}\) | \(E_0/\times10^{51}\)\(\mathrm{ergs}\) | \(N_H/\times10^{21}\)\(\mathrm{cm}^{-2}\) | \(\mathrm{kT}/\mathrm{KeV}\) | \(B/\mu G\) | \(M_\odot/\mathrm{M}_\odot\) | Ref.    |
|----------------|---------------------|-------------------|--------------------------|---------------------------|--------------------------|----------------|--------|----------------|--------|
| G322.5−0.1     | 45                  | —                 | —                        | —                         | —                        | —              | —      | —              | 92W    |
| G326.3−1.8     | 41                  | —                 | —                        | 1.0                       | 8.9                      | —              | 45     | —              | 995WC, 00DMS |
| G327.1−1.1     | 46                  | 600               | 0.1                      | 0.23                      | 18                       | 0.37           | 65     | 49             | 995WC  |
| G327.4+0.4     | 29                  | —                 | 0.39                     | 0.14                      | 22                       | 0.71           | —      | 34             | 02ETM, 05KON |
| G327.6+14.6    | 19                  | 5160?             | 0.1                      | 1.0                       | —                        | 0.1, 1.1       | 39     | —              | 05WLH, 06V, 89BGL |
| G328.4+0.2     | 25                  | —                 | —                        | 0.9-1.8                    | 100                      | 4.0            | 220    | —              | 00HSP  |
| G330.0+15.0    | 63                  | —                 | —                        | 0.005-0.008               | 0.5                      | 0.18-0.32      | —      | —              | 90GGL, 06KGK |
| G330.2+1.0     | 33                  | —                 | —                        | —                         | —                        | —              | —      | —              | 83CHMb |
| G332.4−0.4     | 9                   | 10-20             | 100?                     | —                         | —                        | 0.5            | —      | 4000           | 06PRP, 89BGL |
| G332.4+0.1     | 22                  | 5000?             | —                        | —                         | 40                       | 1              | —      | —              | 04V    |
| G337.0−0.1     | 5                   | —                 | —                        | —                         | —                        | 1100?          | —      | —              | 00BFG, 04AH |
| G337.2−0.7     | 26                  | —                 | —                        | —                         | 32-35                     | 0.74-0.85      | —      | —              | 06RBG  |
| G337.3+1.0     | 22                  | —                 | —                        | —                         | —                        | —              | —      | —              | 89MCK  |
| G337.8−0.1     | 27                  | —                 | —                        | —                         | —                        | —              | —      | —              | 98KFG  |
| G340.4+0.4     | 36                  | —                 | —                        | —                         | —                        | —              | —      | —              | 83CHMa |
| G340.6+0.3     | 29                  | —                 | —                        | —                         | —                        | —              | —      | —              | 83CHMa |
| G341.9−0.3     | 35                  | —                 | —                        | —                         | —                        | —              | —      | —              | 83CHMa |
| G342.0−0.2     | 50                  | —                 | —                        | —                         | —                        | —              | —      | —              | 83CHMa |
| G343.1−2.3     | 19                  | \(\leq500\)       | 0.00023?                 | —                         | 2-5                      | —              | —      | —              | 02BG   |
| G346.6−0.2     | 19                  | —                 | —                        | —                         | —                        | 1700?          | —      | —              | 98KFG, 04AH |
| G347.3−0.5     | 104                 | 5500              | 0.01                     | 0.02                      | —                        | 35             | —      | \(\leq3\)     | 05MTT  |
| G348.5−0.0     | 21                  | —                 | —                        | —                         | —                        | 850?           | —      | —              | 91KBBW, 00BFG |
| G349.7+0.2     | 9                   | 710               | 5-25                     | 0.5                       | 70                       | 0.8/1.4        | 300    | 160            | 05Lsh, 00BFG |
| G351.2+0.1     | 22                  | —                 | —                        | —                         | —                        | —              | —      | —              | 83CHMc |
| G352.7−0.1     | 17                  | —                 | 0.1                      | 0.2                       | 29                       | 2.0            | —      | —              | 98KTT   |
| G355.9−2.5     | 30                  | —                 | —                        | —                         | —                        | —              | —      | —              | 83CHMc |
| G357.7−0.1     | 7                   | 140?              | —                        | —                         | —                        | —              | —      | 15000          | 88GK, 89SFS |
| G357.7+0.3     | 45                  | 670               | 0.025                    | 0.11                      | —                        | —              | —      | —              | 99YGR, 89L |
| G359.0−0.9     | 33                  | 670               | 0.055                    | 0.21                      | —                        | —              | —      | —              | 89L    |
| G359.1−0.5     | 37                  | —                 | —                        | —                         | —                        | —              | —      | —              | 03YMR  |