The Relation Between The Surface Brightness and The Diameter for Galactic Supernova Remnants

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Abstract

In this work, we have constructed a relation between the surface brightness ($\Sigma$) and diameter (D) of Galactic C- and S-type supernova remnants (SNRs). In order to calibrate the $\Sigma$-D dependence, we have carefully examined some intrinsic (e.g. explosion energy) and extrinsic (e.g. density of the ambient medium) properties of the remnants and, taking into account also the distance values given in the literature, we have adopted distances for some of the SNRs.

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which have relatively more reliable distance values. These calibrator SNRs are all C- and S-type SNRs, i.e. F-type SNRs (and S-type SNR Cas A which has an exceptionally high surface brightness) are excluded. The Sigma-D relation has 2 slopes with a turning point at $D=36.5$ pc: 

$$\Sigma(\text{at 1 GHz})=8.4^{+19.5}_{-6.3} \times 10^{-12} \text{ D}^{-5.99^{+0.38}_{-0.33}} \text{Wm}^{-2} \text{Hz}^{-1} \text{ster}^{-1} \text{ (for } \Sigma \leq 3.7 \times 10^{-21} \text{ Wm}^{-2} \text{Hz}^{-1} \text{ster}^{-1} \text{ and } D \geq 36.5 \text{ pc) and }$$

$$\Sigma(\text{at 1 GHz})=2.7^{+2.1}_{-1.4} \times 10^{-17} \text{ D}^{-2.47^{+0.20}_{-0.16}} \text{Wm}^{-2} \text{Hz}^{-1} \text{ster}^{-1} \text{ (for } \Sigma > 3.7 \times 10^{-21} \text{ Wm}^{-2} \text{Hz}^{-1} \text{ster}^{-1} \text{ and } D < 36.5 \text{ pc).}$$

We discussed the theoretical basis for the $\Sigma$-D dependence and particularly the reasons for the change in slope of the relation were stated. Added to this, we have shown the dependence between the radio luminosity and the diameter which seems to have a slope close to zero up to about $D=36.5$ pc. We have also adopted distance and diameter values for all of the observed Galactic SNRs by examining all the available distance values presented in the literature together with the distances found from our $\Sigma$-D relation.


1 Introduction

In the last 40 years it is known that there is a rough relation between the surface brightness value (Σ) in the radio band and the diameter (D) of Supernova remnants (SNRs) (Shklovsky 1960; Poveda & Woltjer 1968; Clark & Caswell 1976; Caswell & Lerche 1979; Milne 1979; Lozinskaya 1981; Sakhibov & Smirnov 1982; Allakhverdiev et al. 1983a; Allakhverdiev et al. 1983b; Huang & Thaddeus 1985; Allakhverdiev et al. 1986c; Green 1984; Li & Wheeler 1984; Mills et al. 1984; Berkhuijsen 1986; Case & Bhattacharya 1998).

If the whole SNR is bright and extends in a medium with roughly homogenous density then both its radio flux, F (mostly at 1 GHz), and its angular diameter, θ can be measured precisely. But in most of the cases, as the radiation coming from some parts of the SNR has low intensity the whole of the shell can not be observed (Green’s catalog 2001; Caswell & Lerche 1979; Milne 1979; Allakhverdiev et al. 1986b). Also in some cases, as the SNR is projected onto a HII region its angular size and its flux can not be measured precisely (Weiler & Panagia 1978; Israel 1980; Blandford & Cowie 1982; Allakhverdiev et al. 1983b; Mills et al. 1984; Allakhverdiev et al. 1986a). As well known:

\[ \Sigma \propto \frac{F}{\theta^2} \propto D^{-n} \]  

If only the bright part of the SNR is seen then the Σ of the remnant will be overestimated, because the measured value of θ will be smaller than the real value of the angular size. What will be the effect of such an error on the distance value found from the Σ-D relation? From Eqn.1:

\[ D \propto \frac{\theta^{2/n}}{F^{1/n}} \]  

Using Eqn.2 we can find a relation between distance (d), θ and F:

\[ d = \frac{D}{\theta} \propto \frac{\theta^{2-n}/n}{F^{1/n}} \]  

If n=2 then overestimation (underestimation) of the Σ (θ) value has no effect on estimation of the distance value. If n > 2 then overestimation (underestimation) of the Σ (θ) value leads to overestimation of the distance value and
the degree of overestimating the distance value increases with n. If n < 2 (which is not the case for the Σ-D relation as we will see below and this is known from various previously suggested Σ-D relations) the distance value will be underestimated in the case of underestimating (overestimating) the Σ (θ) value. An HII region projected onto the SNR may lead to overestimation of the flux value of the SNR and in such a case, from Eqn.3, there will be an underestimation of the distance value.

Observationally, SNR distances are found in general using the shift value of 21 cm HI line and galactic rotation models. By this method, for some of the SNRs (for which the radial velocity is large enough) distances can be found with percentage errors of about 30%-50% at best. The error increases in the vicinity of longitudes l=0° and l=180° and when a SNR is in or close to the galactic center direction 2 values of distance, which are very different from each other, are found. If the SNR is found to be related with some other objects (which are located relatively close to the Sun) its distance can be determined more precisely, but in any case, error in the distance value is not smaller than about 20-30%. So, in order to find distances of the SNRs, particularly the ones located at >3-4 kpc, Σ-D relation is needed.

In Figure 1 we see that the dispersion of the positions of the calibrators (the SNRs which are used to calibrate the Σ-D relation) from the Σ-D relation is very high. The reasons for such high dispersions, in other words, the reasons for the Σ-D relation being not very reliable are discussed in detail by Allakhverdiev et al. (1986b).

The increase in number of reliable calibrators do not decrease the dispersions much (Allakhverdiev et al. 1986b). The reasons for such dispersions are:

1) Explosion energies of supernovae (SNe) vary in a wide range, about 3 orders of magnitude (e.g. kinetic energy of Crab SNR is \(\sim 10^{49}\) erg, Sollerman et al. 2000, whereas kinetic energy of Cas A SNR is \(>10^{51}\) erg, Vink et al. 1998; Wright et al. 1999). So, it is important for constructing the Σ-D relation to examine the differences between the energies of calibrator SNRs. For example, SNR G11.2-0.3 has an explosion energy \(E\sim 10^{48}-2.4\times 10^{49}\) erg (Bandiera et al. 1996), whereas SNR G320.4-1.2 has \(E\sim (1-2)\times 10^{51}\) erg (Gaensler et al. 1999b). For SNR G109.1-1.0 the energy may even be larger: \(E\sim 10^{51}-10^{52}\) (Morini et al. 1988).

2) Surface brightness of a SNR depends on density of the interstellar medium in which it expands as well as the kinetic energy of the expanding matter.
The denser the medium is the higher the surface brightness will be under similar velocities (it must be noted that the lifetime of a SNR, in other words the time needed for the SNR’s surface brightness to drop below a certain value, directly depends on the density of the medium and the SN explosion energy).

3) If there is a very active neutron star (NS) within the SNR which has a significant contribution to the SNR’s energy, then the central part of the SNR can be much more bright.

There are 231 SNRs observed up to date (Green, 2001). 155, 18 and 8 of them are S, C and F-type, respectively. For 50 of them type is either not known or not reliable. Naturally, number of SNRs increase as the SNRs are examined more precisely and as some new SNRs are found, but the increase in their number does not significantly change the ratio between different morphological types of SNRs. As S and C-type SNRs have very different characteristics compared to F-type SNRs and as there are not many F-type SNRs, Σ-D relation is constructed only for S and C-type SNRs and F-type remnants are not used as calibrators. As C-type SNRs are not different from S-type SNRs with respect to their energy and birth sites and because of the radiation coming from the plerionic part often being very low compared to the radiation coming from the shell, they can be used as calibrators for Σ-D relation. In general, for C-type SNRs the radiation coming from the shell is larger than the radiation coming from the plerionic part. But it must be noted that among the SNRs with D>20 pc the largest surface brightness values belong to the remnants W44, W28, RCW 89 and Milne 56 all of which are C-type SNRs.

2 Supernova Remnants as Calibrators

We examined the SNRs given in Green (2001) and also some recently found SNRs with at least one observationally found distance value collecting radio, X-ray, and in some cases optical data of the SNRs. Among these SNRs we chose the ones with reliable distance values as calibrators to construct the Σ-D relation. The data of these SNRs which are essential for the Σ-D dependence and responsible for the deviations from the Σ-D dependence are given below (section 2.3). The calibrator SNRs are presented in the order of their galactic longitude (l) values and the calibrators with relatively more
reliable distance values are presented before the calibrators with relatively less reliable distance values. All the calibrators are represented with asterisk (*) sign in Table 1. In Table 1, we represented the distances calculated using the Σ-D relation, the adopted distance values, the values of surface brightness and luminosity at 1 GHz for all of the Galactic SNRs. While adopting the distances of the SNRs which are not calibrators, we have taken into account the distance values given in the literature, the data about the surrounding matter, the Galactic coordinates, and the Σ-D distances. The data and the references about the SNRs which were not adopted as calibrators, were taken from Tagieva (2002). In Table 1, PSRs (P), X-ray pulsars (XP), pulsar wind nebula (PWN), anomalus X-ray pulsars (AXP), dim radio quiet neutron stars (D) connected to SNRs are also shown in the third column.

2.1 Abbreviations for SNR Data

1. SNR type: S-Shell, C-Composite
2. Angular size for the shell and the plerionic part as a whole: θ (arcmin)
3. Radio spectral index for the shell and the plerionic part separately and for the whole SNR: α
4. Distance: d (kpc)
5. Column density of neutral hydrogen (HI): $N_{\text{HI}}$ cm$^{-2}$
6. Interstellar optical absorption: $A_V$ (mag)
7. Radio flux at 1 GHz: $F_1$ (mJy)
8. Flux in X-ray band: $F_X$ erg/cm$^2$s
9. Temperature of plasma in the shell: $kT$ (keV)
10. Velocity of shock front or expansion velocity: $V$ (km/s)
11. Surface brightness: $\Sigma$ (Wm$^{-2}$Hz$^{-1}$sr$^{-1}$)
12. Radio luminosity at 1 GHz: $L_1$ (Jy erg s$^{-1}$)
13. Luminosity in X-ray band: $L_X$ (erg/s)
14. For density of the SNR environment and types of clouds:
   a) Molecular cloud: MC
   b) Maser source (formed due to interaction between SNR and MC): MS
   c) Dust cloud: DC
   d) Neutral and ionized hydrogen clouds: HI and HII clouds
   e) Number density of particles in front of SNR, in shell, in plerionic part, in different types of clouds and filaments: $n$ (cm$^{-3}$)
15. Kinetic energy of SNR: $E_k$ (erg)
16. Explosion energy of SN: $E$ (erg)
17. Age of SNR: $t$ (kyr)
18. X-ray radiated mass: $M_X$ ($M_\odot$)
19. Ejected mass: $M_{Ej}$ ($M_\odot$)
20. Swept-up mass: $M_S$ ($M_\odot$)
21. Total mass: $M$ ($M_\odot$)
22. Magnetic field in the shell: $B$ (Gauss)

### 2.2 Abbreviations for Data of Point Sources Genetically Connected with SNRs

1. Types of point sources:
   a) Radio pulsar: PSR
   b) X-ray pulsar: XRP
   c) X-ray point source: XPS
   d) Neutron star: NS
2. Distance of point source from the geometrical center of SNR: $\beta=\Delta\theta/\theta$
   ($\Delta\theta$: angular distance of point source from the geometrical center of SNR; $\theta$: average value of angular size of SNR)
3. Characteristic age of pulsar: $\tau$ (kyr)
4. Dispersion measure: $DM$ pc cm$^{-3}$

Values of $F_1$, $\theta$ and $\alpha$ for SNRs were taken from Green (2001). Adopted distance values which were used in constructing the $\Sigma$-D diagram are also given below.

### 2.3 Calibrator Supernova Remnants

**SNR G4.5+6.8**

d=$4.8\pm1.4$ kpc [1], 5 kpc [2], 4.5$\pm$1 kpc [3], 4.1$\pm$0.9 kpc [4], d=4.4 kpc from the historical date and d=4.8-6.4 kpc from HI line measurements [5], d=4.8 kpc adopted.

Kepler is about 500 pc above the galactic plane that it must be in a very low-density medium. So, its surface brightness must be much less than the surface brightness value corresponding to its diameter and its distance must be much less than the distance value found from the $\Sigma$-D relation.

[1] Reynoso & Goss 1999; [2] Borkowski et al. 1992; [3] Bandiera 1987; [4]
SNR G6.4-0.1

d=3.5-4 kpc [1,20], d=2.5 kpc [2], d=2.5 kpc adopted.

In the direction of this SNR, at 1.6 kpc, there is SGR OB1 association. Interstellar absorption, $A_V$, and $N_{HI}$ values of the stars, which are members of this association ($l = 5^\circ.97 - 7^\circ.16$, $b = -0^\circ.48 - +0^\circ.62$), are $\sim 1^m$ and $\sim 2 \times 10^{21}$ cm$^{-2}$, respectively [3].

$N_{HI}=(7-11) \times 10^{21}$ cm$^{-2}$, $N_{HI}=3.5 \times 10^{21}$ cm$^{-2}$ [4], $N_{HI}=4.7 \times 10^{21}$ cm$^{-2}$ [5,6]; $E(B-V)=1-1.3^m$ [4].

Since the SNR has $A_V=3-4^m$ and $N_{HI} > 3.5 \times 10^{21}$ cm$^{-2}$ its distance is assumed to be considerably larger than the OB association’s distance.

MS [10,13,16,17]; MC $n=10^5$ cm$^{-3}$ [9,10], $n=2.5 \times 10^4$ cm$^{-3}$ [11,12], $n=2.5 \times 10^4$ cm$^{-3}$ [13,15,16], $n=30$ cm$^{-3}$ (the average value in the shell) [14], $n_0=0.1$ cm$^{-3}$ [4], $n_0=0.23$ cm$^{-3}$ (the average value in front of the SNR) [6].

$E=10^{51}$ erg [4], $E=4 \times 10^{50}$ erg [6]; $F_x=6.2 \times 10^{-11}$ erg cm$^{-2}$s (0.5-2.4 keV) [6]; $t=2.5 \times 10^3$ yr [4], $t=(1-2.5) \times 10^4$ yr [6], $t=(3.5-15) \times 10^4$ yr [7,8], $t=6 \times 10^4$ yr [14]; $M_x=(19-26)$ $M_\odot$ [4]; $B=0.2$ mG (in the shell) [18].

If the SNR’s explosion energy is $10^{51}$ erg, the swept-up matter’s mass must be about $\leq 2 \times 10^4$ $M_\odot$. In order to sweep-up such a mass the average density of the medium must be $n_0 \leq 5$ cm$^{-3}$. The SNR is in a very high-density medium [9,10].

The SNR interacts with the molecular cloud in the east of the SNR and this interaction has increased its radio and X-ray luminosity. There are many maser and HII regions in the field. The relativistic particles have energy of $2 \times 10^{47}$ erg. It is C-type also in the X-ray band. The SNR is expanding in a very thick medium [19].

Since the medium is very dense, the values of the magnetic field and the explosion energy as well as the temperature and the X-ray luminosity must be large that this SNR should be very high above the $\Sigma$-D line.

SNR G31.9+0.0
\(d=8.5\text{ kpc (from 21cm HI line)}\) [1], \(d=7.2\text{ kpc}\) [2], \(d=7.2\text{ kpc (from 21cm HI line)}\) [3,4], \(d=9\text{ kpc}\) [3,4], \(d=8.5\text{ kpc adopted.}\)

\(N_{HI}=2.4\times10^{22}\text{ cm}^{-2}\text{ (0.1-2.4 keV)}\) [3,4].

The SNR is expanding in a dense medium [2]; MC [2]; \(n_0\sim5\text{–}10\text{ cm}^{-3}\) (the average value in front of the SNR) [4], \(n\sim2\times10^5\text{ cm}^{-3}\) (the average value behind the SNR, i.e. for the cloud) [5]; \(M_{\text{total}}\approx700\text{ M}_\odot\) [4].

[1] Green 2001; [2] Frail et al. 1996; [3] Radhakrishnan et al. 1972; [4] Rho & Petre 1996; [5] Reach & Rho 1998.

**SNR G34.7-0.4**

\(d=2.6\text{ kpc}\) [2], \(d=2.5\text{ kpc}\) [3], \(d=2.5\text{ kpc (from 21cm HI line)}\) [4], \(d=2.8\text{ kpc adopted.}\)

\(N_{HI}=(1.6-2.1)\times10^{22}\text{ cm}^{-2}\) [3].

No \(H_2\text{O maser source}\) [9]; MC [1,7,8]; \(n_0=6\text{ cm}^{-3}\) (the average value in front of the SNR) [3], \(n_0=1\text{ cm}^{-3}\) [3].

\(E\approx10^{51}\text{ erg}\) [3]; \(M=10^3\text{ M}_\odot\) [3]; \(B=0.2\text{ mG}\) [10].

Point Source PSR J1856+0113

\(d=2.8\text{ kpc}\) [5,11], \(d=3.3\text{ kpc}\) [6]; \(\tau=2.03\times10^4\text{ yr}\) [11]; \(\beta=0.51\) [13], \(\beta=0.6\) [14].

A pulsar wind nebula (PWN) was found around this pulsar and this PWN is positionally coincident with the EGRET source [12].

[1] Giaconi et al. 1997; [2] Braun et al. 1989; [3] Cox et al. 1999; [4] Green 2001; [5] Kaspi 2000; [6] Taylor et al. 1996; [7] Frail et al. 1996; [8] Denoyer 1979a,b; [9] Claussen et al. 1999; [10] Koralesky et al. 1998a; [11] Guseinov et al. 2002; [12] Roberts et al. 2001; [13] Lorimer et al. 1998; [14] Allakhverdiev et al. 1997.

**SNR G54.4-0.3**

\(d=3.3\text{ kpc}\) [1], \(d=3.3\text{ kpc adopted.}\)

MC and OB-associations are present [1]; \(n=30\text{ cm}^{-3}\) for MC [1]; \(M_s\approx5\times10^4\text{ M}_\odot\) [1].

[1] Junkes et al. 1992.

**SNR G74.0-8.5**

\(d=0.8\text{ kpc}\) [1], \(d=0.7\text{ kpc}\) [2], \(d=1.4\text{ kpc}\) [4], \(d=460\text{ pc}\) [5], \(d=1.3\pm0.7\text{ kpc (kinematic distance)}\) [3], \(d=440^{+130}_{-100}\text{ pc (using the shock wave’s velocity and proper motion)}\) [6], \(d=0.8\text{ kpc adopted.}\)

\(E(B-V)=0.08\text{ m}\) [3] (As the absorption in this direction is small [7], this value is in accordance with a distance value of about 0.8-1 kpc).

There is no open cluster in the direction of this SNR. In this direction, between 0.8-1.5 kpc, the reddening is almost constant [7].
SNR G78.2+2.1

d=1.2 kpc [1], d=1.5 kpc [2,3,4,5,6], d=1.5 kpc adopted.

MC [2]; \( n_0 \geq 4 \text{ cm}^{-3} \) [2].

The SNR is probably expanding inside a cavity [7].

\( E_k = 1.7 \times 10^{49} \text{ erg} \) (for the shell) if d=1.5 kpc [2]; \( M_x = 10^2 \text{ M}_\odot \) [7].

In the direction of the SNR \((l = 76^\circ.8, b = 1^\circ.44)\), at d=1.37 kpc, there is Cygnus OB-association in which there are many massive stars [8].

Point Source RX J2020.2+4026 [9]

SNR G109.1-1.0

\( d=4 \text{ kpc} \) [1], d=3.6 kpc [2], d=5 kpc [5,12], d=5.6 kpc [9], d=6 kpc [13], d=5 kpc adopted (since, the SNR is in a very dense medium and its explosion energy is high).

\( E(B-V) = (0.79-1.2)^m \) [3]; \( N_{HI} = (8-10) \times 10^{21} \text{ cm}^{-2} \) [4], \( N_{HI} = 4 \times 10^{21} \text{ cm}^{-2} \) [5].

kT=0.17-0.56 keV [7]; \( F_x = 7.8 \times 10^{-11} \text{ erg cm}^{-2} \text{s} \) (0.2-2.4 keV) [7]; \( L_x = 3.2 \times 10^{37} \text{ erg/s} \) [7].

MC [6,8]; \( n=20 \text{ cm}^{-3} \) (for the clouds) [3,11], \( n_0 = 0.25 \text{ cm}^{-3} \) (the average value in front of the SNR) [5]. \( E=10^{51} - 10^{52} \text{ erg} \) [5].

Point Source AXP 1E 2259+586

\( d=5.6 \text{ kpc} \) [9]; \( N_{HI} = 9 \times 10^{21} \text{ cm}^{-2} \) [7], \( N_{HI} = 9.3 \times 10^{22} \text{ cm}^{-2} \) (0.5-20 keV) [10].

SNR G114.3+0.3

\( d=3.0 - 3.8 \text{ kpc} \) [1], d=2.5-3 kpc [2,3], d=2.8 kpc adopted.

\( n_0 = 0.1 \text{ cm}^{-3} \) (the average value for the medium) [4].

The SNR’s shell expanded inside a HII region and has reached to the boundary of the HII region [4].

This SNR together with the SNRs G116.5+1.1 and G116.9+0.2 (CTB 1)
are inside a supercavity [4].

In the direction of the SNR (l = 115°.5, b = 0°.25), at d=2.3 kpc, there is Cas 5 OB association [5].

Point Source PSR J2337+6151 [6]
d=2.5 kpc (from 21cm HI line) [7], d=2.5 kpc [6], d=2.8 kpc [8]; \( \tau = 4.07 \times 10^4 \) yr [8,11]; \( \beta = 0.08 \) [9,10].

SNR G116.9+0.2

\[ d = 3.1 \text{ kpc } [1], \ d = 2.3 \text{ kpc } [2], \ d = 2.8 - 4 \text{ kpc } [3], \ d = 3.5 \text{ kpc adopted.} \]

\[ N_{HI} = 7 \times 10^{21} \text{ cm}^{-2} [5]; \ A_V = 2.2 - 3.2 \] [6].

In the direction of this SNR, at 2.5 kpc, there is an O6-type star (HD/BD 108). For this star \( N_{HI} = 3 \times 10^{21} \text{ cm}^{-2} [4] \) that the SNR’s distance must be larger than the distance of this star.

In this direction, there is no star formation region beyond 3 kpc. If the distance of this SNR is \( \sim 2.7 \) kpc, then it may be in the star formation region which include CAS OB2 and CAS OB5 associations. There is also a young open cluster (C2355+609, t=4×10^7 yr) at about 3.7 kpc in this direction [8].

For the stars in this direction, located at 1-4 kpc, \( A_V \sim 2m \) and does not reach a value of 3m [7].

The SNR is expanding in a low-density supercavity which also include G114.3+0.3 and G116.5+1.1. The shock wave front does not have a regular but a discontinuous shape [6].

SNR G119.5+10.2

\[ d = 1.4 \text{ kpc } [1,2,3,4,5], \ d = 1.4 \text{ kpc adopted.} \]

\[ N_{HI} = 2.8 \times 10^{21} \text{ cm}^{-2} [3], \ N_{HI} = (1.1-2.5) \times 10^{21} \text{ cm}^{-2} [2], \ N_{HI} = 3.8 \times 10^{21} \text{ cm}^{-2} [7]; \ A_V = 1.3 [5]. \]

MC [7]; n\~1 cm\(^{-3}\) (for the clouds in front of the SNR) [5], \( n_0 \sim 0.03 \text{ cm}^{-3} \) (the average value in front of the SNR) [5], \( n_0 \sim 0.02 \text{ cm}^{-3} \) (the average value in front of the SNR) [2].

\[ E = 3 \times 10^{49} \text{ erg} [2]; \ M_* = 13 \text{ M}_\odot [2]; \ B = 2.9 \times 10^{-6} \text{ G} [2]. \]

OIII emission line (\( \lambda = 5010 \text{ A}, \Delta\lambda = 28 \text{ A} \)) is very strong as in SNRs
G65.3+5.7 and G126.2+1.6 [8].

Point Source RX J0007.0+7302 [6]

[1] Pineault et al. 1993; [2] Seward et al. 1995; [3] Slane et al. 1997; [4] Brazier et al. 1998; [5] Mavromatakis et al. 2000; [6] Brazier & Johnston 1999; [7] Rho & Petre 1998; [8] Fesen et al. 1981.

**SNR G120.1+1.4**

d=2.2 kpc [1], d=2.3 kpc (from shock wave velocity model), d=4-5 kpc (from 21cm HI line) [2], d=4.6 kpc [3], d=3 kpc (from X-ray observations of Ginga satellite) [4], d=3.3 kpc adopted.

\[ A_V = 2.1 \pm 0.5 \] [5].

In the direction of this SNR, there are Cas OB4 (at 2.7 kpc; \( l = 118^\circ - 121^\circ \), \( b = -2^\circ.7 - +2^\circ.3 \)) and Cas OB7 (at 1.8 kpc; \( l = 121^\circ.8 - 124^\circ.2 \), \( b = -0^\circ.5 - +2^\circ.7 \)) associations [8]. If the distance of this SNR is less than 3 kpc, i.e. if it is located close to the OB associations, its diameter must be less than 6 pc. Then, how can it be possible that the surface brightness of this young S-type SNR located in a dense medium is much less than the surface brightness value corresponding to its diameter? On the other hand, if Tycho’s distance is close to 4 kpc, then the SNR may be in a low-density medium that its surface brightness can be such a low value [6,7].

[1] Albinson 1986; [2] Green 2001; [3] Schwarz et al. 1995; [4] Fink et al. 1994; [5] Chevalier et al. 1980; [6] Reynoso et al. 1999; [7] Reynoso et al. 1997; [8] Garmany & Stencel 1992.

**SNR G132.7+1.3**

d=2.2±0.2 kpc (from 21cm HI line) [1], d=2.2 kpc [2], d=2.7 kpc [3], d=2.2 kpc (from optical data) [4], d=2.3 kpc adopted.

The SNR’s center is bright in X-ray [5].

\[ N_{HI} \sim 3 \times 10^{21} \text{ cm}^{-2} \] [5], \( N_{HI} = 6.9 \times 10^{21} \text{ cm}^{-2} \) [6]; \( N_{HI} = 4.3 \times 10^{21} \text{ cm}^{-2} \) [10]; \( E(B-V) = 0.71 \) [7].

The SNR interacts with the gas in the star formation region [1]. There are HII regions around the SNR [4]. HB3 is expanding in a dense medium [5].

\[ kT = 0.33 \text{ keV} \] [10]; \( E = 3.1 \times 10^{50} \text{ erg} \) [6].

Point Source PSR J0215+6218

d=2.3 kpc [8], d=3.2 kpc [9]; \( \tau = 1.3 \times 10^7 \text{ yr} \) [9].

[1] Routledge et al 1991; [2] Green 2001; [3] Braun et al. 1989; [4] Gray et al. 1999; [5] Rho et al. 1998; [6] Galas et al. 1980; [7] Fesen et al. 1995a; [8] Lorimer et al. 1998; [9] Guseinov et al. 2002; [10] Rho & Petre 1998.
SNR G166.0+4.3

d=4.5 kpc [2], d=3 kpc [3,4], d=3.8 kpc adopted.

The SNR’s center is bright in X-ray [6,7,8].

In this direction, there is no identified star formation region at this distance, but the outer arm (Persei) of the galaxy is passing through. There is AUR OB2 association in the direction l = 172° - 174°, b = −1°.8 - +2°.0 at 3.2 kpc. The distance of the SNR from the galactic plane at 4.5 kpc is 340 pc. Because of these the SNR is expected to be in a low-density medium.

\[ N_{HI} = 2.9 \times 10^{21} \text{ cm}^{-2} \] [5].

The SNR is expanding in a low-density cavity [8].

[1] Landecker et al. 1989; [2] Green 2001; [3] Allakhverdiev et al. 1986b; [4] Braun et al. 1989; [5] Guo & Burrows 1997; [6] Pineault et al. 1987; [7] Rho et al. 1994; [8] Fesen et al. 1997.

SNR G180.0-1.7

d=0.8 kpc [1], d=1 kpc (by identifying some indications of the SNR in the spectrums of the stars in front of and behind the SNR) [2], d=1 kpc adopted (since distances of stars are used to find the distance of the SNR, this value is much more reliable).

[1] Braun et al. 1989; [2] Phillips et al. 1981.

SNR G189.1+3.0

d=1.5 kpc [1,2,3], d=1.5-2 kpc (from the interaction of the SNR with the MC [10], d=1.5 kpc adopted.

\[ N_{HI} = (1-3) \times 10^{21} \text{ cm}^{-2} \] [3].

MC [5,6]; n=10-20 cm\(^{-3}\) (the average value in front of the SNR) [8].

In the north-eastern part \(V \geq 100\) km/s and the density in front is \(n=10-1000\) cm\(^{-3}\), whereas in the southern part \(V \geq 30\) km/s and the density in front is \(n=10^4\) cm\(^{-3}\) [8].

Not an H\(_2\)O maser source [7].

In the near infrared region the SNR’s luminosity is \(1.3 \times 10^{36}\) erg/s [8].

In the direction of the SNR (l = 188°.9, b = 3°.44), at d=1.34-1.65 kpc, there is Gem OB1 association in which there are 16 massive stars [11,12].

\[ B=500 \mu G \] [4].

Point Source CXOU J061705.3+222127 [9]

In this region there is a point X-ray source [4]; \(N_{HI}=1.3 \times 10^{21} \text{ cm}^{-2} \) [9,4].

The radio flux at 327 MHz of the X-ray point source is not greater than 2 mJy [9].

[1] Fesen 1984; [2] Allakhverdiev et al. 1986b; [3] Asoaka & Aschenbach
SNR G260.4-3.4

d=1.5 kpc [1], d=2 kpc [2], d=2.2±0.3 kpc (from 21cm HI line) [3,4], d=1.9-2.5 kpc [5], d=1.3±0.6 kpc [6], d=2 kpc adopted.

\[ N_{HI} = (2-6) \times 10^{21} \text{ cm}^{-2} \] [7], \[ N_{HI} = (2.9-4.7) \times 10^{21} \text{ cm}^{-2} \] [5,8], \[ N_{HI} = 1.4 \times 10^{21} \text{ cm}^{-2} \] [9].

There is a B0.7 Ib type star (HD 69882; l = 259°.5, b = −3°.9, d=2.1 kpc) in the same region of Puppis A and for this star \[ N_{HI} = 1.6 \times 10^{21} \text{ cm}^{-2} \] [10].

Puppis A is in the direction of Vela X and, like the star formation regions in this part of the galaxy, it is below the geometrical plane of the galaxy.

Puppis A is not exactly in the direction of the star formation regions. Distances of the OB associations in the star formation region do not exceed 1.5-1.8 kpc [11,12].

On the other hand, it is seen from the distribution of neutral hydrogen (HI) in the galaxy that the cold clouds in the direction of Puppis A are in general nearer than 1.5-1.8 kpc [1].

Diameter of this SNR has reached to 32 pc and it has gone out of the HII region it was in. Eastern part of the remnant is interacting with the HI cloud [3].

There are OH clouds in front of the SNR, but no sign of an interaction between the SNR and the clouds has been found [6].

\[ n_0 \approx 0.4-0.5 \text{ cm}^{-3} \] (the average value in front of the SNR) [3], \[ n = 100 \text{ cm}^{-3} \] (for X-ray emitting region) [1], \[ n = 10-1000 \text{ cm}^{-3} \] (for clouds) [3], \[ n_0 = 3 \text{ cm}^{-3} \] (the average value in front of the SNR) [7], \[ n_0 = 1 \text{ cm}^{-3} \] [9].

N, O and Ne are abundant in the SNR [2].

Point Source RX J0822-4300 [13]

\[ N_{HI} = (4-8) \times 10^{21} \text{ cm}^{-2} \] [2].

The region <30" around the pulsar in the SNR has been examined. The upper limit of the radio luminosity of a possible pulsar-powered nebula is 3 orders of magnitude less than what would be expected if RX J0822-4300 was an energetic young radio pulsar beaming away from us. RX J0822-4300 has some properties which are very different compared to most of the young pulsars’ properties [14].

[1] Braun et al. 1989; [2] Petre et al. 1996; [3] Reynoso et al. 1995; [4] Green 2001; [5] Zavlin et al. 1999; [6] Woermann et al. 2000; [7] Winkler et
al. 1981a,b; [8] Blair et al. 1995; [9] Berthiaume et al. 1994; [10] Diplas & Savage 1994; [11] Melnik & Efremov 1995; [12] Humphreys 1978; [13] Pavlov et al. 1999; [14] Gaensler et al. 2000b.

**SNR G263.9-3.3**

Recent distance estimates of Vela are as follows: $d=0.25$ kpc [1], $d=0.25\pm0.03$ kpc [2], $d\sim0.28$ kpc [3], $d=0.25,0.3$ kpc [14]. The stars which are in front of, behind, and interacting with Vela have been identified [4]. The distance of Vela is given as $250\pm30$ pc in [4].

In estimating the distance one should also consider that Vela SNR expands in a dense environment. Its magnetic field is $B\sim6\times10^{-5}$ G [5] and its explosion energy is $(1-2)\times10^{51}$ erg [4]. These values have large errors, but the values themselves are also large. If we take all of these values into account, then, in the $\Sigma$-D diagram, it is not acceptable to put Vela at the same position with SNR G327.6+14.6 (remnant of type Ia supernova explosion at 500 pc above the galactic plane [6]) which expands in a low-density medium.

In the direction of Vela remnant, none of the young open clusters nor OB associations have distances as small as 0.25 kpc [7],[8],[9]. Among the open clusters in the direction of Vela SNR (none of them has a distance value as small as 0.25 kpc) Pismis 4 ($l = 262^\circ.7, b = -2^\circ.4$) and Pismis 6 ($l = 264^\circ.8, b = -2^\circ.9$), which have the most precise distance values and are exactly in the direction of Vela SNR, are located at 0.6 kpc and 1.6 kpc, respectively [1]. Since progenitors of SNRs (and pulsars) are massive stars one would expect Vela to be closer to the star formation region instead of a distance value of 0.25 kpc.

If the distance value of 0.45 kpc (which is close to the previous distance estimation of 0.5 kpc [10]) is adopted for Vela PSR, then the average electron density along the line of sight will be $n_e=0.153$ cm$^{-3}$. The pulsar with the second largest $n_e$ value ($\sim0.113$ cm$^{-3}$) is for PSR J1302-6350 ($l = 304^\circ.2, b = -0^\circ.9, d=1.3$ kpc, with a Be type companion, variable wind in the environment) and the third largest $n_e$ value (0.107 cm$^{-3}$) belongs to PSR J1644-4569 ($l = 339^\circ.2, b = -0^\circ.2$). Since the flux of PSR J1644-4569 at 1400 MHz is larger than any other known pulsars’ flux value at the same frequency, we can estimate its distance as not more than 4.5 kpc. Average value of $n_e$ for the rest of pulsars is about 0.04 cm$^{-3}$ [13]. So, it is not possible to accept a distance value of 0.25 kpc for Vela pulsar and Vela SNR. All we could do is to reduce our initial distance estimate of 0.45 kpc to at most 0.4 kpc.
V=170 km/s [11]; kT=0.086-0.17 keV [12]; A_V=0.56 [11]; E=(1-2)×10^{51} erg [4]; B~6×10^{-5} G [5].

From the above discussion d=0.45 kpc adopted.

Point Source PSR J0835-4510
DM=68.2 cm^{-3}pc; d=0.5 kpc [15]; τ=1.1×10^4 yr [13,15]; β=0.29 [16], β=0.3 [17].

[1] Ogelman et al. 1989; [2] Cha et al. 1999; [3] Bocchino et al. 1999; [4] Danks 2000; [5] de Jager et al. 1996; [6] Hamilton et al. 1997; [7] Efremov 1989; [8] Berdnikov & Efremov 1993; [9] Aydin et al. 1997; [10] Green 2000; [11] Raymond et al. 1997; [12] Kahn et al. 1985; [13] Guseinov et al. 2002; [14] Green 2001; [15] Taylor et al. 1996; [16] Lorimer et al. 1998; [17] Allakhverdiev et al. 1997.

SNR G296.5+10.0
d=1.5 kpc [1,2,3], d=1-2 kpc [4], d=2.1 kpc [5], d=1.8 kpc adopted.

N_HI=1.4×10^{21} cm^{-2} (d=1-2 kpc) [6], N_HI=(1.1-1.6)×10^{21} cm^{-2} (d=1-2 kpc) [5], N_HI=4×10^{20} cm^{-2} (0.1-10 keV) [7], N_HI=4×10^{20} cm^{-2} [2]; A_V(r)=0.5^{m}
(d=1-2 kpc) [8].

n_0=0.2 cm^{-3} (the average value in front of the SNR) [7], E=2×10^{50} erg [7], E=6×10^{50} erg (d=1-2 kpc) [4], E>2×10^{49} erg [5].

Mass of the neutral hydrogen in the SNR is more than 1900 M_⊙ (d=1-2 kpc) [5].

Point Source 1E 1207.4-5209 [2,5]
There is a hole in the HI clouds, at exactly the center of the SNR and the neutron star is located at this position that it is genetically connected with the SNR [5].

[1] Kaspi et al. 1996; [2] Mereghetti et al. 1996; [3] Zavlin et al. 2000; [4] Roger et al. 1988; [5] Giacani et al. 2000; [6] Kellett et al. 1987; [7] Vasisht et al. 1997; [8] Ruiz 1983.

SNR G315.4-2.3
d=2.8 kpc [1,2], d=2.5 kpc [3,4], d=2.8 kpc (kinematic) [6], d=2.5 kpc [10], d=2.5 kpc (the SNR is located in an OB-association) [13], d=2.7 kpc adopted.

N_HI=(1-4)×10^{21} cm^{-2} [2,5], N_HI=3×10^{21} cm^{-2} [10].

n_0=0.2 cm^{-3} (the average value in front of the SNR), n=10 cm^{-3} (for the clouds) [6], n=0.2 cm^{-3} (the average value in front of the SNR) [12], n_0=0.3 cm^{-3} (the average value in front of the SNR) [13]; E=6.6×10^{50} erg [6].

The part of the remnant, which is bright in radio, is also bright in X-ray [7]. X-ray synchrotron radiation has been observed [7,8,9].
The abundances of O, Ne, Mg, and Si are more than the abundance of Fe that the SNR was formed due to a type-II supernova [10].

The SNR’s morphology looks like the morphology of Tycho. The SNR has expanded inside a cavity and now it seems that it is expanding in the boundary of the cavity. This leads to a rapid drop in SNR’s expansion velocity [11].

In the direction of the SNR (l = 315°.5, b = −2°.75), at d=2.5 kpc, there is Cir OB1 association [14].

[1] Greidanus & Strom 1992; [2] Petruk 1999; [3] Braun et al. 1989; [4] Green 2001; [5] Nugent et al. 1984; [6] Rosado et al. 1996; [7] Borkowsky 2001; [8] Allen et al. 1998; [9] Asvarov et al. 1990; [10] Bamba et al. 2000; [11] Dickel et al. 2001; [12] Long & Blair 1990; [13] Borkowsky et al. 2001; [14] Blaha & Humphreys 1989.

SNR G320.4-1.2

\( \text{d}=3.6 \text{ kpc [1]}, \text{d}=4 \text{kpc [2]}, \text{d}=5.2 \text{ kpc (from 21cm HI line) [3]}, \text{d}=5.2 \text{ kpc [4]}, \text{d}=4 \text{kpc [11]}, \text{d}= 4.2 \text{ kpc adopted.} \)

\( N_{HI}=9\times10^{21} \text{ cm}^{-2} [5], N_{HI}=9.5\times10^{21} \text{ cm}^{-2} [6], N_{HI}=6\times10^{21} \text{ cm}^{-2} [7]. \)

\( n=100 \text{ cm}^{-3} \) (in the X-ray emitted part) [1]; \( E=(1-2)\times10^{51} \text{ erg} [4]; M=28 M_\odot \) (possible) [10]; \( B\sim 8\times10^{-6} \text{ G} \) (in the plerionic part) [10].

Point Source PSR J1513-5908 [8,9]

\( \text{d}=4.2 \text{ kpc [9,12]}; N_{HI}=5.9\times10^{21} \text{ cm}^{-2} [11]; \tau=1.55\times10^{3} \text{ yr [9,12];} \beta=0.24 [13]; \) a jet has been observed [11].

[1] Braun et al. 1989; [2] Allakhverdiev et al. 1986b; [3] Green 2001; [4] Gaensler et al. 1999a; [5] Seward et al. 1984; [6] Greiveldinger et al. 1995; [7] Trussoni et al. 1996; [8] Allakhverdiev et al. 1997; [9] Taylor et al. 1996; [10] du Plessis et al. 1995; [11] Tamura et al. 1996; [12] Guseinov et al. 2002; [13] Lorimer et al. 1998.

SNR G327.6+14.6

\( \text{d}=0.7\pm0.1 \text{ kpc (from Sedov’s model) [1], d}=1.5-2.5 \text{ kpc [8], d}=1.7-3.1 \text{ kpc [4]}, \text{d}=2 \text{kpc [7], d}=1.8\pm0.3 \text{ kpc [2,3,4], d}=2 \text{kpc adopted.} \)

\( N_{HI}=(3.9-5.7)\times10^{20} \text{ cm}^{-2} [1], N_{HI}=1.8\times10^{21} \text{ cm}^{-2} [9]; A_V=0.31 [10]. \)

\( n_0=0.4 \text{ cm}^{-3} \) (ambient density) [1], \( n_0=0.1 \text{ cm}^{-3} \) (in front of the SNR) [12], \( n_0\sim 0.02 \text{ cm}^{-3} [11]. \)

\( E>4.4\times10^{49} \text{ erg} [1], E=10^{51} \text{ erg} [12]. \)

\( B=(6-10)\times10^{-6} \text{ G} [9], B=(3-6)\times10^{-6} \text{ G} [12]. \)

Using the age (\( t\sim 1000 \text{ yr} \)) and the expansion velocity (16600 km/s) of this SNR its diameter is found to be \( \sim 17 \text{ pc.} \) As the angular diameter of SN
1006 is 30′ the lower limit for its distance value should be 1.9 kpc [5,6,7].

[1] Willingale et al. 1996; [2] Long et al. 1988; [3] Roger et al. 1988; [4] Green 2001; [5] Fesen 1988; [6] Wu et al. 1993; [7] Winkler & Long 1997; [8] Schaefer 1996; [9] Koyama et al. 1995; [10] Laming et al. 1996; [11] Krishner et al. 1987; [12] Reynolds 1996.

**SNR G332.4-0.4**

$d=4$ kpc [9], $d=3.7$ kpc adopted.

$A_V=4.5^m$ [1]. This value is comparable with the average $A_V$ value of 6.3$^m$ [3] for the stars at $d=3.4$ kpc [2] in this direction. The distance has mostly been assumed to be 3.3 kpc [4,5,6,7].

In the direction of RCW 103, there is R103 cluster located at 4 kpc [8].

MC [15]; $n>1000$ cm$^{-3}$ (for the clouds) [8], $n\geq 1000$ cm$^{-3}$ (for the MC) [14]. Density of the gas clouds behind the shock wave is relatively low ($n_e\sim 10^3$ cm$^{-3}$) [11].

The SNR’s angular radius has increased 1″.8±0″.2 in 25 years [13].

$N_{HI}=6.8\times10^{21}$ cm$^{-2}$ [10] value shows the possibility that RCW 103 might be related with the cluster R103. If the SNR is in the same region with the cluster, then it is possible that the remnant is expanding in a dense medium.

The SNR has an approximately spherical shape. It is bright and has a thick shell. Northern part of the shell interacts with the molecular cloud. The SNR can be assumed to have formed due to a supernova explosion 1000 years ago [12].

[1] Oliva et al. 1990; [2] Caswell et al. 1975; [3] Neckel & Klare 1980; [4] Tuohy & Garmire 1980; [5] Gotthelf et al. 1997; [6] Kaspi et al. 1996; [7] Green 2001; [8] Braun et al. 1989; [9] Allakhverdiev et al. 1986b; [10] Gotthelf et al. 1999b; [11] Oliva et al. 1999; [12] Dickel et al. 1996; [13] Carter et al. 1997; [14] Meaburn & Allan 1986; [15] Frail et al. 1996.

**SNR G5.4-1.2**

$d=4.5$ kpc (from 21cm HI line) [1], $d\approx 5$ kpc [2], $d>4.3$ kpc (from 21cm HI line) [3], $d=4.5$ kpc adopted.

$n_0>3\times10^{-3}$ cm$^{-3}$ (in front of the SNR) [4].

**PSR J1801-2451**

SNR - PSR J1801-2451 connection [1,4], $d=4.5$ kpc [6], $d=4.4$ kpc [5]; $\tau=1.5\times10^4$ yr [5,6]; $\beta=0.8$ [7], $\beta\sim 1$ [8].

[1] Frail et al. 1994b; [2] Caswell et al. 1987; [3] Green 2001; [4] Frail & Kulkarni 1993; [5] Taylor et al. 1996; [6] Guseinov et al. 2002; [7] Allakhverdiev et al. 1997; [8] Lorimer et al. 1998.
SNR G11.2-0.3
\(d=5 \text{ kpc (from 21cm HI line)}\) [1], \(d=5 \text{ kpc adopted.}\)

\(N_{HI} \approx 10^{22} \text{ cm}^{-2}\) [3], \(N_{HI} = 1.38 \times 10^{22} \text{ cm}^{-2}\) [4]; \(E \sim 10^{48} - 2.4 \times 10^{49} \text{ erg}\) [2]; \(t \sim 2 \text{ kyr}\) [7].

Point Source AX J1811-1926
\(d=5 \text{ kpc}\) [5]; \(\tau = 2.4 \times 10^4 \text{ yr}\) [6].

If the pulsar’s real age is \(2.4 \times 10^4 \text{ yr}\) and if the SNR is a historical one, then the two age values contradict with each other. The possibility of a genetic connection between the radio-quiet pulsar and the SNR is examined in [7].

[1] Green 2001; [2] Bandiera et al. 1996; [3] Reynolds et al. 1994; [4] Vasisht et al. 1996; [5] Kaspi 2000; [6] Torii et al. 1999; [7] Roberts et al. 2000.

SNR G43.3-0.2
\(d=8.5 \text{ kpc}\) [1], \(d=12.5-14 \text{ kpc (from 21cm HI line)}\) [2], \(d=9 \text{ kpc adopted.}\)

\(N_{HI} = 4 \times 10^{22} \text{ cm}^{-2} (0.5-10 \text{ keV})\) [3].

The medium around the SNR seems to be highly dense from X-ray observations [4].

[1] Braun et al. 1989; [2] Green 2001; [3] Fujimoto et al. 1995; [4] Hwang et al. 1999.

SNR G69.0+2.7
\(d=1.3 \text{ kpc}\) [1], \(d=2 \text{ kpc adopted; } E=10^{51} \text{ erg.}\)

Point Source J1952+3252 (radio and X-ray pulsar) [4]
\(d=2.5 \text{ kpc}\) [2,3,4], \(d=2 \text{ kpc}\) [5]; \(N_{HI} = 3 \times 10^{21} \text{ cm}^{-2}\) [2,3]; \(\tau = 1.07 \times 10^5 \text{ yr}\) [4,5]; \(\beta = 0.14\) [6], \(\beta = 0.15\) [7].

[1] Braun et al. 1989; [2] Safi-Harb et al. 1995; [3] Ögelman & Buccheri 1987; [4] Taylor et al. 1996; [5] Guseinov et al. 200; [6] Lorimer et al. 1998; [7] Allakhverdiev et al. 1997.

SNR G89.0+4.7
\(d=0.8 \text{ kpc (from the connection of the remnant with the association Cyg OB7)}\) [1,2], \(d=0.9 \text{ kpc adopted.}\)

[1] Huang & Thaddeus 1986; [2] Tatematsu et al. 1990.

SNR G93.3+6.9
\(d=3.8 \text{ kpc}\) [1], \(d=2.5 \text{ kpc (from 21cm HI line)}\) [2], \(d=3.8 \text{ kpc adopted (z=420 pc, } D=26 \text{ pc).}\)

\(N_{HI} = 5.7 \times 10^{21} \text{ cm}^{-2}\) [2]; \(E=3.9 \times 10^{50} \text{ erg}\) [1].

The type-Ia supernova has exploded 5000 years ago [1].
As this SNR is in a very low-density medium, its position on the Σ-D diagram should be well below the Σ-D line.

[1] Landecker et al. 1999; [2] Green 2001.

**SNR G156.2+5.7**

The data from ROSAT X-ray satellite were examined using Sedov model. Taking the results found from this model and \( N_{HI}=8.8 \times 10^{20} \text{ cm}^{-2} \) value into account \( d=3 \) kpc [1,3]. \( d=1.3 \) kpc [4]; \( D=100 \) pc if \( d=3 \) kpc [4].

\[ N_{HI}=9 \times 10^{20} \text{ cm}^{-2} \ [2,3]. \]

There is no star formation region in the direction of this SNR, but there is an open cluster for which the distance is not known. Both of the distance values correspond to \( z>100 \) pc (for \( d=1.3 \) kpc \( z=130 \) pc). The facts that there is no star formation region in this direction and that \( z>130 \) pc show that the remnant is in a low-density medium. So, the SNR’s diameter (and distance) is not expected to be larger than the diameter value corresponding to its surface brightness in the Σ-D diagram. The diameter might be less than the diameter corresponding to its surface brightness. As a result, \( d=2 \) kpc adopted (\( z=200 \) pc).

[1] Pfeffermann et al. 1991; [2] Yamauchi et al. 1993; [3] Reich et al. 1992; [4] Yamauchi et al. 1999.

**SNR G205.5+0.5**

d=0.8 kpc (from optical data), \( d=1.6 \) kpc (from radio data) [1], \( d=1.6 \) kpc [2], \( d=1 \) kpc adopted.

[1] Green 2001; [2] Odegard 1986.

**SNR G111.7-2.1**

d=2.8 kpc [1], \( d=3.4 \) kpc (by examining the SNR’s dynamics) [2].

Cas A has no projection on the OB-associations and none of these OB-associations, which are in the directions close to the SNR, has a distance >3 kpc [3,4].

\[ N_{HI}=1.2 \times 10^{21} \text{ cm}^{-2} \ [5]; \ E\sim 10^{51} \text{ erg} [6,10]. \]

\[ M_s+M_{Ej}=7-12 \text{ M}_{\odot} \ [5]; \ M_{Ej}\sim 4 \text{ M}_{\odot}; \ M_s+M_{Ej}\sim 12 \text{ M}_{\odot} \ [6]. \]

Since Cas A was born because of a massive star’s explosion in a dense interstellar medium, its distance was adopted as 3 kpc. This SNR was not used as a calibrator.

**Point Source RQNS CXO J2323+5848** [7]

d=3.4 kpc [9]; \( N_{HI}=1.1 \times 10^{22} \text{ cm}^{-2} \ [8]; \ A_V=5^m \ [9]. \)

[1] Green 2001; [2] Reed et al. 1995; [3] Humphreys 1978; [4] Garmany & Stencel 1992; [5] Favata et al. 1997; [6] Vink et al. 1998; [7] Brazier &
SNR G130.7+3.1
d=3.2 kpc [1,2,3,4,5], d=2.2 kpc [6], d=2.6 kpc [7], d=3 kpc adopted.
The SNR is plerion in X-ray.
$N_{HI}=1.8\times10^{21}$ cm$^{-2}$ (2-10 keV) [1,8], $N_{HI}=2\times10^{21}$ cm$^{-2}$ (0.5-4.5 keV) [9], $N_{HI}=(3-4)\times10^{21}$ cm$^{-2}$ [10], $N_{HI}=3\times10^{21}$ cm$^{-2}$ [3].
$A_V=1.3\pm0.2$ (if this value is correct, then, according to [11] d<1 kpc); B=3\times10^{-3}$ G [10].

X and radio PSR J0205+6449 [12,13]
d=3.2 kpc [14]; $\tau=5.5\times10^3$ yr [14].

SNR G184.6-5.8
d=2 kpc [1], d=2 kpc adopted.
$N_{HI}=3\times10^{21}$ cm$^{-2}$ [3]; E(B-V)=0.52$^m$ [3]; R=3.1$^m$ [3].
$E\sim10^{49}$ erg; $L_x=10^{37}$ erg/s (2-10 keV) [5], $L_x=2.5\times10^{37}$ erg/s [6].
$\Sigma<4.3\times10^{22}$ Wm$^{-2}$Hz$^{-1}$ster$^{-1}$ (if the SNR has a shell) [2].
The CIV ion’s line at $\lambda=1550$ A shows that there may be a shell near Crab moving with a velocity of 2500 km/s. $E=1.5\times10^{49}$ erg [3].

Point Source J0534+2200
d=2 kpc; $\beta\sim0.1$ [4]; $\tau=1.26\times10^3$ yr [7,8].

After examining the data of these SNRs and the point sources in them, we adopted distance values for the SNRs.
Among the 34 SNRs given above the first 23 ones have the most reliable distance values. For the next 8 SNRs the distance values are relatively less reliable. The last 3 SNRs presented above (Cas A (G111.7-2.1), Crab (G184.6-5.8), and SN 1181 (G130.7+3.1)) were not chosen as calibrators; the surface brightness value of Cas A is extraordinarily high and, Crab and SN 1181 are F-type SNRs. These SNRs are shown on the $\Sigma$-D diagram, be-
cause their distances are known precisely and their diameters are small. We included them in the Σ-D diagram just to see their positions on the diagram.

3 Constructing Σ-D Relation Using Calibrators

Using the 31 SNRs given above (for which reliable distance values were determined) we constructed the Σ-D relation (Fig. 1). In the Σ-D diagram, F-type historical SNRs Crab and SN 1181, for which the distances are well known, are shown as cross (x) signs. As mentioned above, for F-type SNRs Σ-D relation can not be used, though the positions of Crab and SN 1181 are shown on the Σ-D diagram just to see deviations of their positions from the Σ-D relation.

SNR Cas A has the highest energy among the Galactic SNRs which were formed by SN explosion in the last two thousand years (for all of these SNRs dates of explosion are known). The massive shell of Cas A is expanding through a dense medium, so that, the magnetic field behind the shock wave is more intense and the situation is more convenient in order to accelerate the electrons (independent of the acceleration mechanism). Because of these reasons Cas A, for which the distance is well known, deviates from the Σ-D line more than the other SNRs (Σ < 10^{-18} Wm^{-2}Hz^{-1}ster^{-1}) do. In our galaxy, this SNR has the highest Σ (and also luminosity) value and it’s very high Σ value makes it unique.

As seen from Fig.1, the historical SNRs G4.5+6.8 (Kepler), G332.4-0.4 (RCW 103) and G327.6+14.6 (SN 1006) are located below the Σ-D line. Since, Kepler and SN 1006 are very far away from the Galactic plane they are expanding in a low-density medium and because of this they have surface brightness values much less than the surface brightness values corresponding to their diameters. SNRs G43.3-0.2 (W49B), G6.4-0.1 (W28), G320.4-1.2 (RCW89) and G132.7-1.3 (HB3) are located above the Σ-D line.

For the calibrator SNRs shown in Fig.1 two Σ-D relations with different slopes were constructed; one for the SNRs having Σ ≤ 3.7×10^{-21} Wm^{-2}Hz^{-1}ster^{-1} (D ≥ 36.5 pc) and the other for the SNRs with Σ > 3.7×10^{-21} Wm^{-2}Hz^{-1}ster^{-1} (D < 36.5 pc):

\[
Σ = 8.4^{+19.5}_{-6.3} × 10^{-12} D^{-5.99^{+0.38}_{-0.33}} Wm^{-2}Hz^{-1}ster^{-1}
\]  (4)
and
\[ \Sigma = 2.7^{+2.1}_{-1.4} \times 10^{-17} D^{-2.47^{+0.20}_{-0.16}} Wm^{-2}Hz^{-1}ster^{-1} \]  \hspace{1cm} (5)

Since we have used the flux values at 1 GHz given in Green (2001) these equations are valid only for 1 GHz frequency.

In Fig.2, the relation between radio luminosity (at 1 GHz) and diameter values of the calibrator SNRs shown in Fig.1 are given. Similar to the \( \Sigma-D \) relation, we found 2 equations for L-D relation with an intersection at \( L=5300 \text{ Jy kpc}^2, D=36.5 \text{ pc} \); one for the SNRs having \( L > 5300 \text{ Jy kpc}^2 \), \( D < 36.5 \text{ pc} \) and the other for the SNRs having \( L \leq 5300 \text{ Jy kpc}^2 \), \( D \geq 36.5 \text{ pc} \):
\[ L = 2.45 \times 10^4 D^{-0.43} \text{ Jy kpc}^2 \] \hspace{1cm} (6)
and
\[ L = 5.38 \times 10^9 D^{-3.84} \text{ Jy kpc}^2 \] \hspace{1cm} (7)

These dependences are not as reliable as the \( \Sigma-D \) dependences given above (Eqns. 4 and 5) that we did not give their errors which are very large. Similar to the \( \Sigma-D \) diagram, in Fig.2 Cas A and Crab have very high radio luminosities. Considering the other calibrator SNRs (except SNRs G156.2+5.7 and G114.3+0.3 which have reliable distance and radio luminosity values) we see that the luminosity decreases only a bit with respect to the diameter (see Fig.2). Does radio luminosity of SNRs actually change only a little bit until their diameters reach to values 40-50 pc?

If, during the evolution of SNRs, L(F) value does not really change much then the slope of the \( \Sigma-D \) relation must be \(-2\) (i.e. \( \Sigma \sim D^{-2} \)), but no one has claimed that such an equation for SNRs is valid, yet. In this work, such an equation is not valid for all the calibrator SNRs, either.

The most contribution for the luminosity seen to be almost constant is mainly due to the SNRs W44 (G34.7-0.4), W28 (G6.4-0.1) and RCW 89 (G320.4-1.2) which are in very high-density medium. As it is known that, the ejected mass of Type I SN is less than the ejected mass of Type II SN, but expansion velocity of Type I SNe’s remnants is greater, about 15000 km/s on average. If such a remnant expands in a very low-density medium (as often is the case), then in a very short time it can reach to a large diameter of about SNR SN1006’s diameter. For such a case, dense ultra-relativistic particles and high magnetic fields can not be expected. So that, such SNRs have low luminosity and surface brightness values corresponding to their diameters in the L-D and \( \Sigma-D \) diagrams.

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This is also true for SNR G4.5+6.8 (Kepler, SN1604) which is in the galactic center direction and 570 pc above the galactic plane. As Kepler’s age and diameter are 400 yr and 4 pc, respectively, its radio luminosity being 5.5 times higher than SN1006’s radio luminosity is normal (see Fig.2). This shows that for S-type SNRs expanding through low-density medium the luminosity decreases considerably, about 5 times, even only in 1000 years.

As seen in Fig.1, the S-type SNR G93.3+6.9 (DA530, z=420 pc), which is the third most distant SNR from the galactic plane (after Kepler and SN 1006), also is well below the \( \Sigma-D \) line. This Ia type SN is assumed to have been formed 5000 years ago. Its explosion energy is \( 3.9 \times 10^{50} \) erg. Its diameter is 26 pc (Landecker et al. 1999). Since this SNR is in a very low-density medium, it has a low luminosity (see Fig.2). It must be noted that, errors in age and explosion energy values of SNRs are not small, because these values are found using some not-so-precise observational data and theoretical models.

The other S-type SNRs with respect to their distances from the galactic plane are, respectively: G166.0+4.3 (VRO 42.05.01, z=277), G296.5+10 (PKS1209-51/52, z=261), and G119.5+10.2 (CTA 1, z=248 pc). Among these, G166.0+4.3 is located in the outer (Persei) arm of the Galaxy. There is a sharp increase in reddening values of the stars located between 3-4 kpc in the direction of this SNR (Neckel & Klare 1980) that the density of dust in this region should be high. So, this SNR can not be assumed to expand in a low-density medium. On the other hand, since SNRs G296.5+10 and G119.5+10.2 are absolutely out of star formation regions, they can be assumed to be in lower density medium. Because of this, their surface brightness and luminosity values are low as expected (see Fig.1 and Fig.2).

As seen in Table 1 and Figs. 1 and 2, SNR G156.2+5.7 has the lowest surface brightness and radio luminosity values among the calibrator SNRs. We can say that Kepler and SN 1006-like SNRs will have such low surface brightness and radio luminosity values when their diameters reach to about 60-70 pc.

In \( \Sigma-D \) and L-D diagrams, SNRs G156.2+5.7, Kepler and SN1006 are roughly on the same lines that these lines can be assumed to be the evolutionary tracks of S-type SNRs which evolve in very low-density medium. The equations of these tracks are (D in pc):

\[
\Sigma = 5 \times 10^{-17} D^{-3.32} \, W m^{-2} Hz^{-1} ster^{-1} \quad (8)
\]
\[ L = 3 \times 10^4 D^{-1.16} \ J_y \ \text{pc}^2 \] (9)

From the definitions \( \Sigma \sim F/\theta^2 \) and \( L \sim F \ d^2 \), the relation between \( \Sigma \) and \( L \) is:

\[ \Sigma \sim L/D^2 \] (10)

Using the \( \Sigma-D \) equations (4) and (5) for the SNRs having diameters greater than and less than 36.5 pc, and Eqn.10 we can find 2 equations; one for the SNRs having smaller diameters:

\[ L \sim D^{-0.47} \] (11)

and the other one for the SNRs having larger diameters:

\[ L \sim D^{-4} \] (12)

If we compare these 2 equations with Eqns. (6) and (7), respectively, we see that the values of powers are very close to each other. Therefore, Eqns. (6) and (7) can be considered to be correct, in principle.

### 4 Theoretical Basis

As known from synchrotron radiation theory, radiation (in radio band) per unit volume at a certain frequency (spectral density) is given as (Ginzburg 1981)

\[ j_\nu = 1.35 \times 10^{-27} b(\alpha)(6.26 \times 10^4)^\alpha K_e B_{-5}^{\alpha+1} \nu_{GHz}^{-\alpha} \ \text{erg cm}^{-3} \ \text{s}^{-1} \ \text{ster}^{-1} \ \text{Hz}^{-1} \] (13)

Here, \( b(\alpha) \) is a function of \( \alpha \), \( B \) is the magnetic field of the region which emits in units of \( 10^{-5} \) Gauss, \( \nu_{GHz} \) is frequency of radiation in units of GHz, \( K_e \) is the coefficient in the energy spectrum (distribution) of ultrarelativistic electrons.

\[ N_e dE = K_e E^{-\gamma} dE \ \text{electron/cm}^3 \] (14)

Here, \( \gamma = 2\alpha + 1 \). In the shells of S- and C-type SNRs electrons are accelerated mainly by regular (Bell-Krymsky) mechanism (Bell 1978a, 1978b; Krymsky 1977). In order to apply this mechanism to SNRs, it is necessary to choose acceptable values for the Bell coefficients (Allakhverdiev et al. 1986d), but here we consider the acceleration under strong shock propagation, in general. This mechanism gives the number and energy distribution of electrons,
which are accelerated in the strong shock wave, in units of density of the medium and velocity of the shock wave. $K_e$, given in Eqn.14, depends on volume density of unaccelerated electrons in the shock wave ($n$) and velocity of the shock wave ($V$):

$$K_e \sim nV^{2\alpha}$$

(15)

If we apply the regular mechanism to the acceleration in the SNR's shock wave we get:

$$j_\nu = 9.69 \times 10^{-30} b(\alpha)(3.41 \times 10^{-9})^\alpha \Phi_e \alpha n V_8^2 B_5^{\alpha+1} \nu_{GHz}^{\alpha-\alpha} \text{ er}g \text{ cm}^{-3} \text{s}^{-1} \text{ster}^{-1} \text{Hz}^{-1}$$

(16)

Here, $V_8$ is the shock wave velocity in units of $10^8$ cm/s and $\Phi_e$ is the constant given by Bell.

As seen from Eqn.16, the radiation of the SNR shell’s unit volume at a certain frequency ($j_\nu$) is related to $n$, $V$, and $B$ for radio radiation with spectral index, $\alpha=0.5$ (note that the spectral indices of S and C-type SNRs are always close to 0.5 and this confirms the Bell mechanism):

$$j_\nu \sim nVB^{1.5}$$

(17)

Using the observational data of SNRs in X-ray, optical, and radio bands Tagieva (2002) showed that

$$n \sim D^{-0.9\pm0.4}, \quad V \sim D^{-1.3\pm0.3}, \quad B \sim D^{-0.8}$$

(18)

Since the magnetic field values are known (with large errors) only of a few of the SNRs, it is not yet possible to find a relation between $B$ and $D$ directly from observations. If the dynamo mechanism to increase the magnetic field is not working, then, as magnetic field is freezed to gas, $B\sim n^{2/3}\sim D^{-0.6}$. If the dynamo is also working a bit, we can roughly assume that $B\sim D^{-0.8}$ as in Eqn.18. Using the relations of Eqn.18 in Eqn.17:

$$j_\nu \sim D^{-3.4}$$

(19)

Shock wave front expands like a shell that its volume increases roughly with $D^2$. Because of this, luminosity is:

$$L_\nu \sim D^2 j_\nu$$

(20)
From Eqns. 19 and 20:

\[ L \sim D^{-1.4} \]  \hspace{1cm} (21)

This is roughly in agreement with the average power of the L-D equations (Eqns. 6 and 7) found from the L-D diagram (Fig.2). But using this single equation, instead of using the 2 L-D equations, leads to results with larger errors for some of the SNRs.

As known from observations, while SNR’s diameter is increasing most of the parts of the shock wave front do not interact with interstellar clouds, so that, behind the wave front some large low-density regions form. In these regions, as the value of magnetic field intensity is smaller, high-energy ultrarelativistic electrons can hardly be trapped. The electrons in denser regions of the wave front move along the magnetic field lines, which are very disordered, and, after reaching the low-density regions, they can also leave the SNR. It must be noted that, for SNRs with D\( \sim \)40 pc the magnetic field, on average, is (2-6) \( \mu \)G (Seward et al. 1995; du Plessis et al. 1995; for G93.7-0.3 \( B=2.3 \) \( \mu \)G, Uyaniker et al. 2001). The lifetime of ultrarelativistic electrons is:

\[ t(\text{yr}) \approx \frac{3 \times 10^2}{H^2(Gauss)E(eV)} \]  \hspace{1cm} (22)

Energy and lifetime of the ultrarelativistic electrons, which radiate in such magnetic fields at 1 GHz, are not less than \( \sim 5 \times 10^3 \) MeV and \( 4 \times 10^4 \) yr; the lifetime of ultrarelativistic electrons is comparable to the average lifetime of SNRs that, not only the new-accelerated electrons but mainly the electrons which have already been accelerated do produce the radiation of SNRs. As these electrons leave the low-magnetic field regions of the SNR, the SNR’s radiation decreases rapidly. So that, in most of the cases, the part of the shell, which is farther away from the Galactic plane (where the number density of clouds is low), is less bright (Caswell & Lerche 1979; Allakhverdiev et al. 1983b). Since such a decrease in the radiation is more effective in large-diameter SNRs, the slope of the \( \Sigma \)-D equation for such SNRs should be larger.

5 Discussion and Conclusions

In this work, we have constructed the \( \Sigma \)-D relation for C and S-type SNRs. We have also adopted distance and diameter values for all of the Galactic
SNRs given in the Galactic SNRs catalog of Green (2001) and also for some recently found SNRs. Although the SNR nature of Sgr A East (G0.0+0.0) and G10.0-0.3 is uncertain, we have included them in Table 1, because they are given in the Galactic SNRs catalog (Green 2001).

As mentioned in the introduction, in the last 45 years many $\Sigma$-D relations were constructed and presented in the literature. In some of these works a single linear dependence between Log $\Sigma$ and Log $D$ values of calibrator SNRs was given. In other works 2 linear dependences (with 2 different slopes) were given. The most recent $\Sigma$-D dependence was given by Case & Bhattacharya (1998): $\Sigma(1 \text{ GHz}) = 2.07^{+3.10}_{-1.24} \times 10^{-17} D^{-2.38^{+0.26}_{-0.26}} \text{ Wm}^{-2}\text{Hz}^{-1}\text{ster}^{-1}$ (Cas A is not included).

As seen above, in Case & Bhattacharya (1998) the relation between $\Sigma$ and $D$ is given with only one equation, instead of two, for the whole set of calibrators. The reason of this is that, for some of the calibrator SNRs having small surface brightness values ($\Sigma < 10^{-21} \text{ Wm}^{-2}\text{Hz}^{-1}\text{ster}^{-1}$), they assume diameter (distance) values larger than the values which we have adopted to construct our $\Sigma$-D relation (which includes 2 equations with 2 different slopes). So, for small-$\Sigma$ calibrator SNRs the adopted diameters (distances) given in Case & Bhattacharya (1998) are larger than the diameters (distances) which we have adopted. It is necessary to compare and discuss the SNRs for which the differences in the adopted distance values are the largest. For example, for SNRs G156.2+5.7, G166.0+4.3, G180.0-1.7, and G205.5+0.5 the distances adopted by Case & Bhattacharya (1998) and by us (given in brackets) are, respectively: 3.0 (2.0) kpc, 4.5 (3.8) kpc, 1.5 (1.0) kpc, and 1.6 (1.0) kpc. In Section 2.3, we discussed the distance values of these calibrator SNRs in detail.

There are 3 SNRs which were considered as calibrators by Case & Bhattacharya (1998), but excluded by us in constructing the $\Sigma$-D dependence: G116.5+1.1, G160.9+2.6, and G166.2+2.5. The adopted diameter values of these SNRs given in Case & Bhattacharya (1998) differ significantly from our adopted diameter values (Table 1). The distance values of these SNRs according to Case & Bhattacharya (1998) and the distance values of the SNRs adopted by us (given in brackets) are, respectively: 5 (3.5) kpc, 3.0 (1.2) kpc, and 4.5 (2.7) kpc. We will discuss the distance values of these 3 SNRs below.

For SNR G116.5+1.1 $d=3.6-5.2$ kpc (Green 2001) and $d=4.4$ kpc (Reich & Braunsfurth 1981; Lorimer et al. 1998) values were given. In the direction
of this SNR, there is Persei arm of the Galaxy about 3-4 kpc distant from the Sun. On the other hand, there is no star formation region at \( \sim 5 \) kpc in this direction. In this part of the interstellar medium which is not dense (Fesen et al. 1997), this SNR might reach a diameter of about 70-90 pc at \( d=3.5-4.4 \) kpc.

The supercavity in which SNR G116.5+1.1 is located also include G114.3+0.3 and G116.9+0.2 (Fich 1986). The diameter (distance) of SNR G116.5+1.1 is not expected to be larger than the diameter (distance) of SNR G114.3+0.3, because the surface brightness of SNR G116.5+1.1 is greater than the surface brightness of SNR G114.3+0.3. Also, a few SNRs being located in the same region requires them to be in the Galactic arm. From our \( \Sigma-D \) relation the distance of this SNR is found to be 2.7 kpc. Taking this and the distance values given above into account we have adopted \( d=3.5 \) kpc for SNR G116.5+1.1.

For SNR G160.9+2.6 \( d=1.7 \) kpc (Braun et al. 1989) and \( d<4 \) kpc (Green 2001) were given. From the \( \Sigma-D \) relation \( d=1.2 \) kpc and this value is adopted as the distance of SNR G160.9+2.6. In this direction, between \( d=1-3 \) kpc, the interstellar absorption is almost constant (Neckel & Klare 1980). This shows that the medium (\( d=1-3 \) kpc) has a very low density. In this part of the Galaxy there is no star formation region. So, even for small diameter values, the surface brightness of this SNR must be small.

For SNR G166.2+2.5 \( d=8 \) kpc (Routledge et al. 1986; Green 2001), \( d=4.5 \) kpc (Landecker et al. 1989), and \( d=2 \) kpc (Braun et al. 1989) were given. Since, there is no star formation region at these distances in this direction, this SNR can not be much above the \( \Sigma-D \) line. A distance of 2.5 kpc is found from the \( \Sigma-D \) relation and this value is adopted as the distance of this SNR.

Above, we discussed the escape of relativistic electrons from large-diameter SNRs. Because of this effect, the SNR’s luminosity, and also its surface brightness, should decrease rapidly with respect to the diameter of the SNR. So, the \( \Sigma-D \) dependence of large-diameter SNRs should be sharper (with a larger slope) compared to the the \( \Sigma-D \) dependence of the SNRs which have smaller diameters.

There is also another such effect; at the initial stages of the evolution, SNRs expand within the HII regions which were created by the progenitors of the SNRs. During this time, as the shock wave has a high velocity its temperature is also high that the X-ray radiation will be high. Expansion velocity of the SNR must decrease a lot when the SNR’s shock wave reaches the
HII region’s boundary and interacts with a dense neutral gas and molecular clouds (Lozinskaya 1981; Chevalier 1999; Eikenberry 2002). But at the same time, the rate of drop of the X-ray radiation should decrease as the mass and density of the gas in the shock wave increases. Naturally, a SNR which has a high explosion energy and which is expanding through a dense medium must have a higher X-ray luminosity compared to a SNR with a lower explosion energy expanding through a lower-density medium. It is seen that, after the SNR reaches the boundary of the HII region, which was formed by the progenitor O-type star, a small increase in the SNR’s size will be accompanied by a sharp decrease in the SNR’s radio and X-ray luminosity. Depending on sizes of the HII regions, surface brightness of SNRs will begin to drop sharply at different values of the diameter. We have assumed a value of $D=36.5$ pc as the turn-off point in the $\Sigma$-D relation (which is not an evolutionary track), i.e. after the SNR reaches a diameter of roughly about $36.5$ pc the slope of the $\Sigma$-D relation sharply changes.
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| l,b   | Name    | Type    | Σ    | d_{Σ-D} | D_{Σ-D} | d_{ado} | D_{ado} | L    |
|-------|---------|---------|------|---------|---------|---------|---------|------|
| 0.0+0.0 | SgrAE   | S       | 1.720E-18 | 3.61   | 3.05   | 8.5     | 7.2     | 3.12E+35 |
| 0.3+0.0 | S       | 2.759E-20 | 5.10   | 16.25  | 5.4    | 17.2    | 2.77E+34 |
| 0.9+0.1 | C(PWN)  | 4.233E-20 | 5.90   | 13.66  | 8.0    | 18.5    | 4.98E+34 |
| 1.0-0.1 | S       | 3.527E-20 | 6.35   | 14.71  | 6.4    | 14.8    | 2.66E+34 |
| 1.4-0.1 | S       | 3.010E-21 | 12.97  | 37.72  | 13.0   | 37.8    | 1.46E+34 |
| 1.9+0.3 | S       | 6.271E-20 | 33.75  | 11.65  | 20.0   | 6.9     | 1.04E+34 |
| 3.7-0.2 | S       | 2.248E-21 | 10.99  | 39.6   | 11.0   | 39.6    | 1.20E+34 |
| 3.8+0.3 | S       | 1.858E-21 | 7.81   | 40.88  | 7.8    | 40.8    | 1.05E+34 |
| 4.2-3.5 | S       | 6.143E-22 | 6.04   | 49.18  | 6.9    | 48.8    | 4.98E+33 |
| 4.5+6.8* | Kepler  | S       | 3.177E-19 | 7.14   | 6.04   | 4.8    | 4.1     | 1.89E+34 |
| 4.8+6.2 | S       | 1.394E-21 | 8.19   | 42.89  | 6.2    | 32.5    | 4.99E+33 |
| 5.2-2.6 | S       | 1.208E-21 | 8.39   | 43.93  | 8.4    | 44.0    | 7.93E+33 |
| 5.4-1.2* | Milne 56 | C?(P)   | 4.30E-21 | 3.39   | 34.48  | 4.5    | 45.8    | 3.06E+34 |
| 5.9+3.1 | S       | 1.24E-21  | 7.52   | 43.73  | 7.5    | 43.6    | 8.02E+33 |
| 6.1+1.2 | F       | 7.72E-22  |       |        |        |        |         |     |
| 6.4-0.1* | W28     | C       | 2.64E-20 | 1.18   | 16.53  | 2.5    | 34.9    | 8.38E+34 |
| 6.4+4.0 | S       | 2.04E-22  | 6.56   | 59.14  | 6.5    | 58.6    | 2.38E+33 |
| 7.0-0.1 | S       | 1.67E-21  | 9.53   | 41.61  | 9.5    | 41.5    | 9.75E+33 |
| 7.7-3.7 | 1814-24 | S       | 3.42E-21 | 5.77   | 36.92  | 5.8    | 37.1    | 1.60E+34 |
| 8.7-5.0 | S       | 9.80E-22  | 6.01   | 45.49  | 5.2    | 39.3    | 5.14E+33 |
| 8.7-0.1 | W30     | S?(P)   | 5.95E-21 | 2.31   | 30.24  | 3.5    | 45.8    | 4.24E+34 |
| 9.8+0.6 | S       | 4.08E-21  | 10.11  | 35.24  | 12.0   | 41.8    | 2.43E+34 |
| 10.0-0.3 | ?       | 6.82E-21  | 12.35  | 28.61  | 12.0   | 27.8    | 1.8E+34  |
| 11.2-0.3* | C(XP)  | 2.07E-19  | 6.28   | 7.19   | 5.0    | 5.7     | 2.38E+34 |
| 11.4-0.1 | S?      | 1.41E-20  | 9.20   | 21.32  | 9.2    | 21.3    | 2.20E+34 |
| 12.0-0.1 | ?       | 1.08E-20  | 11.65  | 23.8   | 12.0   | 24.5    | 2.18E+34 |
| 13.3-1.3 | S?      |         |         | ?      | ?      | 3.0     | 46.0    |     |
| 13.5+0.2 | S       | 2.63E-20  | 12.82  | 16.56  | 13.0   | 16.8    | 2.56E+34 |
| 15.1-1.6 | S       | 1.15E-21  | 5.68   | 44.29  | 5.7    | 44.5    | 7.72E+33 |
| 15.9+0.2 | S?      | 2.15E-20  | 10.41  | 17.97  | 11.0   | 19.0    | 2.62E+34 |
| 16.2-2.7 | S       | 1.04E-21  | 9.11   | 45.03  | 8.8    | 43.5    | 6.69E+33 |
| 16.7+0.1 | C       | 2.82E-20  | 14.06  | 16.1   | 16.0   | 18.3    | 3.32E+34 |
| 16.8-1.1 | ?       | 4.18E-22  | 6.72   | 52.44  | 6.7    | 52.3    | 3.88E+33 |
| l,b     | Name      | Type | Σ  | $d_{\Sigma-D}$ | $D_{\Sigma-D}$ | $d_{ado}$ | $D_{ado}$ | L         |
|--------|-----------|------|----|----------------|---------------|-----------|-----------|-----------|
| 17.4-2.3 | S         | 1.25E-21 | 6.25 | 43.66 | 6.3 | 44.0 | 8.24E+33 |
| 17.8-2.6 | S         | 1.05E-21 | 6.45 | 45.01 | 6.4 | 44.7 | 7.08E+33 |
| 18.8+0.3 | Kes 67    | S     | 2.66E-20 | 4.14 | 16.5 | 8   | 31.8 | 9.13E+34 |
| 18.9-1.1 | C?        | 5.11E-21 | 3.35 | 32.15 | 3.4 | 32.6 | 1.85E+34 |
| 20.0-0.2 | F         | 1.51E-20 |      |       |     |     |          |
| 21.5-0.9 | C         | 6.27E-19 | 4.01 | 4.59 | 5.5 | 6.3 | 7.85E+33 |
| 21.8-0.6 | Kes 69    | S     | 2.60E-20 | 2.86 | 16.65 | 2.9 | 16.9 | 2.51E+34 |
| 22.7-0.2 | S?        | 7.35E-21 | 3.67 | 27.76 | 3.7 | 28.0 | 1.95E+34 |
| 23.3-0.3 | W41       | S     | 1.45E-20 | 2.69 | 21.11 | 2.8 | 22.0 | 2.37E+34 |
| 23.6+0.3 | ?         | 1.20E-20 | 7.81 | 22.73 | 8   | 23.3 | 2.21E+34 |
| 24.7-0.6 | S?        | 5.35E-21 | 7.23 | 31.56 | 9   | 39.3 | 2.80E+34 |
| 24.7+0.6 | C?        | 6.69E-21 | 4.68 | 28.84 | 5   | 30.8 | 2.16E+34 |
| 27.4+0.0 | 4C-04.71  | S(AXP)| 5.64E-20 | 10.62 | 12.16 | 6.5 | 7.4  | 1.10E+34 |
| 27.8+0.6 | F         | 3.01E-21 |      |       |     |     |          |
| 28.6-0.1 | S         | 3.86E-21 | 11.45 | 36   | 11.5 | 36.1 | 1.72E+34 |
| 28.8+1.5 | S?        | ?     | ?   | ?    |     |     |          |
| 29.6+0.1 | S(AXP)    | 9.03E-21 | 17.43 | 25.54 | 11 | 16.1 | 7.85E+33 |
| 29.7-0.3 | Kes 75    | C(XP) | 1.67E-19 | 9.26 | 7.83 | 6.7 | 5.7  | 1.94E+34 |
| 30.7-2.0 | ?         | 2.94E-22 | 11.94 | 55.62 | 12 | 55.9 | 3.11E+33 |
| 30.7+1.0 | S?        | 2.09E-21 | 6.63 | 40.09 | 6.6 | 39.9 | 1.13E+34 |
| 31.5-0.6 | S?        | 9.29E-22 | 8.77 | 45.9 | 8.8 | 46.1 | 6.69E+33 |
| 31.9+0.0* | 3C391     | S     | 1.03E-19 | 5.52 | 9.52 | 8.5 | 14.7 | 7.50E+34 |
| 32.0-4.9 | 3C396.1   | S?    | 9.20E-22 | 2.63 | 45.98 | 2.7 | 47.1 | 6.93E+33 |
| 32.1-0.9 | C?        | ?     | ?   | ?    |     |     |          |
| 32.8-0.1 | Kes 78    | S?    | 5.73E-21 | 6.21 | 30.7 | 6.3 | 31.1 | 1.89E+34 |
| 33.2-0.6 | S         | 1.63E-21 | 7.98 | 41.8 | 8   | 41.9 | 9.68E+33 |
| 33.6+0.1 | Kes 79    | S     | 3.31E-20 | 5.19 | 15.09 | 7   | 20.3 | 4.66E+34 |
| 34.7-0.4* | W44       | C(P)  | 3.66E-20 | 1.62 | 14.49 | 2.8 | 25.0 | 7.79E+34 |
| 36.6-0.7 | S?        | ?     | ?   | ?    |     |     |          |
| 36.6+2.6 | S         | 4.77E-22 | 11.86 | 51.31 | 11.6 | 50.2 | 4.07E+33 |
| 39.2-0.3 | 3C396     | S     | 5.64E-20 | 6.04 | 12.16 | 7.7 | 15.5 | 4.61E+34 |
| 39.7-2.0 | W50       | ?     | 1.78E-21 | 1.67 | 41.19 | 5.0 | 124.0 | 9.17E+34 |
| 40.5-0.5 | S         | 3.42E-21 | 5.77 | 36.92 | 5.7 | 36.5 | 1.55E+34 |
| l,b       | Name  | Type | Σ   | d_{Sz-D} | D_{Sz-D} | d_{ado} | D_{ado} | L         |
|-----------|-------|------|-----|----------|----------|---------|---------|-----------|
| 41.1-0.3  | 3C397 | S    | 2.94E-19 | 6.38 | 6.23 | 6.4 | 6.2 | 3.90E+34 |
| 42.8+0.6  |       | S    | 7.84E-22 | 6.76 | 47.22 | 6 | 41.9 | 4.67E+33 |
| 43.3-0.2* | W49B  | S    | 4.77E-19 | 5.25 | 5.13 | 9 | 8.8 | 1.33E+35 |
| 43.9+1.6  |       | S?   | 3.60E-22 | 3.08 | 53.78 | 3.1 | 54.1 | 3.57E+33 |
| 45.7-0.4  |       | S    | 1.31E-21 | 6.77 | 43.36 | 6.7 | 42.9 | 8.15E+33 |
| 46.8-0.3  | HC30  | S    | 9.53E-21 | 5.77 | 24.98 | 7.0 | 30.3 | 2.97E+34 |
| 49.2-0.7  | W51   | S?   | 2.68E-20 | 1.88 | 16.45 | 4.0 | 34.9 | 1.11E+35 |
| 53.6-2.2  | 3C400.2 | S   | 1.30E-21 | 4.91 | 43.38 | 4.5 | 39.8 | 7.00E+33 |
| 54.1+0.3  |       | F    | 3.34E-20 |    |       |   | 10 | 2.16E+33 |
| 54.4-0.3* | HC40  | S    | 2.63E-21 | 3.31 | 38.57 | 3.3 | 38.4 | 1.32E+34 |
| 55.0+0.3  |       | S    | 2.51E-22 | 11.33 | 57.11 | 11.3 | 56.9 | 2.76E+33 |
| 55.7+3.4  |       | S    | 3.98E-22 | 7.91 | 52.87 | 7 | 46.8 | 2.97E+33 |
| 57.2+0.8  | 4C21.53 | S| 1.88E-21 | 11.70 | 40.8 | 11.7 | 40.8 | 1.07E+34 |
| 59.5+0.1  |       | S    | 1.81E-20 | 13.17 | 19.29 | 11 | 16.1 | 1.57E+34 |
| 59.8+1.2  |       | ?    | 7.53E-22 | 9.14 | 47.54 | 9.1 | 47.3 | 5.73E+33 |
| 63.7+1.1  |       | F    | 4.23E-21 |    |       |   |      |          |
| 65.1+0.6  |       | S    | 2.01E-22 | 3.04 | 59.28 | 3 | 58.5 | 2.33E+33 |
| 65.3+5.7  |       | S?   | 1.05E-22 | 0.83 | 66.03 | 0.8 | 63.5 | 1.44E+33 |
| 65.7+1.2  | DA495 | ?    | 2.37E-21 | 7.50 | 39.26 | 7.5 | 39.3 | 1.24E+34 |
| 67.7+1.8  |       | S    | 2.60E-21 | 14.83 | 38.65 | 14 | 36.5 | 1.19E+34 |
| 68.6-1.2  |       | ?    | 1.51E-22 | 8.08 | 62.2 | 8 | 61.6 | 1.94E+33 |
| 69.0+2.7* | CTB80 | ?(P) | 2.82E-21 | 1.64 | 38.13 | 2 | 46.5 | 2.08E+34 |
| 69.7+1.0  |       | S    | 9.41E-22 | 9.83 | 45.8 | 9.5 | 44.2 | 6.24E+33 |
| 73.9+0.9  |       | S?   | 2.80E-21 | 5.96 | 38.18 | 5 | 32 | 9.72E+33 |
| 74.0-8.5* | Cygnus L. | S | 8.59E-22 | 0.83 | 46.5 | 0.8 | 44.6 | 5.81E+33 |
| 74.9+1.2  | CTB87 | F    | 2.82E-20 |    |       |   | 7.9 | 2.43E+34 |
| 76.9+1.0  |       | ?    | 2.79E-21 | 12.61 | 38.21 | 12.6 | 38.2 | 1.37E+34 |
| 78.2+2.1* | DR4   | S(D) | 1.42E-20 | 1.22 | 21.25 | 1.5 | 26.2 | 3.31E+34 |
| 82.2+5.3  | W63   | S    | 2.92E-21 | 1.66 | 37.9 | 1.7 | 38.9 | 1.50E+34 |
| 84.2-0.8  |       | S    | 5.17E-21 | 6.15 | 32 | 5 | 26 | 1.19E+34 |
| 84.9+0.5  |       | S    | 3.34E-21 | 21.05 | 37.06 | 10 | 17.6 | 3.46E+33 |
| 85.4+0.7  |       | S    |  ?     | ? | ? | | | |
| 85.9-0.6  |       | S    |  ?     | ? | ? | | | |
| l,b       | Name     | Type | Σ    | d$_{Σ-D}$ (kpc) | D$_{Σ-D}$ (pc) | d$_{ado}$ (kpc) | D$_{ado}$ (pc) | L (erg/s) |
|-----------|----------|------|------|----------------|--------------|---------------|--------------|-----------|
| 89.0+4.7* | HB21     | S    | 3.07E-21 | 1.24           | 37.6         | 0.9           | 27.2         | 7.70E+33  |
| 93.3+6.9* | DA 530   | S    | 2.51E-21 | 5.75           | 38.89        | 3.8           | 25.7         | 5.62E+33  |
| 93.7-0.2  | DA 551   | S    | 1.53E-21 | 1.82           | 42.24        | 1.6           | 37.2         | 7.19E+33  |
| 94.0+1.0  | 3C434.1  | S    | 3.02E-21 | 4.73           | 37.72        | 4.7           | 37.5         | 1.43E+34  |
| 106.3+2.7 | ?(P)     |      | 6.27E-22 | 4.44           | 49.01        | 5.5           | 60.7         | 7.85E+33  |
| 109.1-1.0*| CTB 109  | S(AXP)| 3.84E-21 | 4.43           | 36.1         | 5             | 40.7         | 2.16E+34  |
| 111.7-2.1 | Cas A    | S(D) | 1.64E-17 | 0.84           | 1.22         | 3             | 4.4          | 1.06E+36  |
| 114.3+0.3*| S(P)     |      | 1.82E-22 | 2.94           | 60.23        | 2.8           | 57.3         | 2.03E+33  |
| 116.5+1.1 | S        |      | 3.45E-22 | 2.69           | 54.16        | 3.5           | 70.5         | 5.82E+33  |
| 116.9+0.2*| CTB 1    | S    | 1.17E-21 | 4.46           | 44.15        | 3.5           | 34.6         | 4.77E+33  |
| 117.7+0.6 | (D)      |      |          |                |              |               |              |           |
| 119.5+10.2*| CTA 1   | S(D) | 6.69E-22 | 1.85           | 48.49        | 1.4           | 36.7         | 3.05E+33  |
| 120.1+1.4*| Tycho    |      | 1.32E-19 | 3.73           | 8.63         | 3.3           | 7.6          | 2.64E+34  |
| 126.2+1.6 | S?       |      | 2.15E-22 | 2.88           | 58.6         | 2.5           | 50.9         | 1.89E+33  |
| 127.1+0.5 | R5       | S    | 9.66E-22 | 3.48           | 45.6         | 2.5           | 32.7         | 3.51E+33  |
| 130.7+3.1 | SN 1181  | F(D) | 1.10E-19 |               | 3.2          | 5.8           | 1.46E+34     |           |
| 132.7+1.3*| HB3      | S    | 1.06E-21 | 1.93           | 44.91        | 2.3           | 53.5         | 1.03E+34  |
| 156.2+5.7*| S        |      | 6.22E-23 | 2.25           | 72.08        | 2.3           | 73.6         | 1.14E+33  |
| 160.9+2.6 | HB9      | S    | 9.85E-22 | 1.21           | 45.45        | 1.2           | 45.2         | 6.85E+33  |
| 166.0+4.3*| VRO      | S    | 5.47E-22 | 3.93           | 50.14        | 3.8           | 48.5         | 4.37E+33  |
| 166.2+2.5 | OA 184   | S    | 2.63E-22 | 2.45           | 56.67        | 2.5           | 57.7         | 2.97E+33  |
| 179.0+2.6 | S?       |      | 2.15E-22 | 2.88           | 58.6         | 2.9           | 59.0         | 2.55E+33  |
| 180.0+1.7*| S 147    | S    | 3.02E-22 | 1.06           | 55.37        | 1             | 52.4         | 2.81E+33  |
| 182.4+4.3 | S        |      | 7.22E-23 | 4.83           | 70.3         | 3.5           | 50.9         | 6.35E+32  |
| 184.6-5.8 | Crab     | F(P) | 4.47E-18 |               | 2            | 3.5           | 1.80E+35     |           |
| 189.1+3.0*| IC 443   | C    | 1.19E-20 | 1.75           | 22.84        | 1.5           | 19.6         | 1.56E+34  |
| 192.8-1.1 | PKS 0607 | S    | 4.95E-22 | 2.25           | 50.99        | 2.3           | 52.2         | 4.57E+33  |
| 205.5+0.5*| Monoceros| S    | 4.98E-22 | 0.80           | 50.94        | 1             | 64.0         | 6.92E+33  |
| 206.9+2.3 | PKS 0646 | S?   | 3.76E-22 | 3.74           | 53.37        | 3.4           | 48.5         | 3.00E+33  |
| 260.4-3.4*| Puppis A | S(D) | 6.52E-21 | 1.83           | 29.13        | 2             | 31.9         | 2.25E+34  |
| 261.9+5.5 | S        |      | 1.25E-21 | 4.33           | 43.66        | 3.3           | 33.3         | 4.71E+33  |
| 263.9-3.3*| Vela     | C(P) | 4.05E-21 | 0.48           | 35.33        | 0.45          | 33.4         | 1.53E+34  |
| 266.2-1.2 | S(D)     |      | 5.23E-22 | 1.45           | 50.53        | 1.0           | 34.9         | 2.16E+33  |
| 272.2-3.2 | S?       |      | 2.68E-22 | 12.94          | 56.5         | 9             | 39.3         | 1.40E+33  |
| l,b     | Name        | Type | Σ     | d_{Σ-D} (kpc) | D_{Σ-D} (pc) | d_{ado} (kpc) | D_{ado} (pc) | L (erg/s) |
|---------|-------------|------|-------|---------------|-------------|--------------|-------------|-----------|
| 279.0+1.1 | S           | 5.00E-22 | 1.84  | 50.9          | 1.8        | 49.7         | 4.20E+33    |
| 284.3-1.8 | MSH10-53    | S(P)  | 2.87E-21 | 5.44       | 38.01      | 5.2          | 36.3        | 1.29E+34  |
| 286.5-1.2 | S?          | 1.35E-21 | 11.85 | 43.12        | 10         | 36.4         | 6.05E+33    |
| 289.7-0.3 | S           | 3.70E-21 | 7.93  | 36.64        | 7.9        | 36.5         | 1.67E+34    |
| 290.1-0.8 | S           | 2.38E-20 | 3.64  | 17.26        | 5.5        | 26.1         | 5.48E+34    |
| 291.0-0.1 | C           | 1.23E-20 | 5.55  | 22.5         | 5.5        | 22.3         | 2.09E+34    |
| 292.0+1.8 | MSH11-54    | C     | 2.35E-20 | 6.09       | 17.33      | 5.0          | 14.3        | 1.62E+34  |
| 292.2-0.5 | S(P)        | 3.51E-21 | 7.30  | 36.76        | 7.5        | 37.8         | 1.70E+34    |
| 293.8+0.6 | C           | 1.88E-21 | 7.01  | 40.8         | 6.9        | 40.1         | 1.03E+34    |
| 294.1-0.0 | S           | >1.88E-22 | ?     | <59.92       | 4         | >1.38E+33    |
| 296.1-0.5 | S           | 1.30E-21 | 4.91  | 43.39        | 4.9        | 43.3         | 8.30E+33    |
| 296.5+10* | PKS1209     | S(D)  | 1.23E-21 | 1.97       | 43.77      | 1.8          | 40.1        | 6.72E+33  |
| 296.8-0.3 | 1156-62     | S     | 4.84E-21 | 6.75       | 32.88      | 6.8          | 33.1        | 1.80E+34  |
| 298.5-0.3 | ?           | 3.01E-20 | 10.71 | 15.68        | 11         | 16.1         | 2.62E+34    |
| 298.6-0.0 | S           | 6.97E-21 | 9.36  | 28.36        | 9.3        | 28.2         | 1.87E+34    |
| 299.2-2.9 | S           | 3.80E-22 | 13.00 | 53.29        | 12         | 49.2         | 3.11E+33    |
| 299.6-0.5 | S           | 8.91E-22 | 12.22 | 46.22        | 12.2       | 46.1         | 6.43E+33    |
| 301.4-1.0 | S           | 3.71E-22 | 6.30  | 53.49        | 6.3        | 53.5         | 3.60E+33    |
| 302.3+0.7 | S           | 2.60E-21 | 7.82  | 38.64        | 7.8        | 38.6         | 1.31E+34    |
| 304.6+0.1 | Kes 17      | S     | 3.29E-20 | 6.53       | 15.13      | 6.5          | 15.1        | 2.56E+34  |
| 308.1-0.7 | S           | 1.07E-21 | 11.86 | 44.84        | 11         | 41.6         | 6.28E+33    |
| 308.8-0.1 | C?(P)       | 3.76E-21 | 5.11  | 36.4         | 8          | 57.0         | 4.15E+34    |
| 309.2-0.6 | S           | 5.85E-21 | 7.79  | 30.44        | 6          | 23.5         | 1.09E+34    |
| 309.8+0.0 | S           | 5.39E-21 | 4.97  | 31.48        | 5          | 31.7         | 1.84E+34    |
| 310.6-0.3 | Kes 20B     | S     | 1.18E-20 | 9.91       | 22.95      | 9.9          | 22.9        | 2.12E+34  |
| 310.8-0.4 | Kes 20A     | S     | 6.27E-21 | 8.49       | 29.6       | 8.5          | 29.6        | 1.87E+34  |
| 311.5-0.3 | S           | 1.81E-20 | 13.17 | 19.29        | 12         | 17.6         | 1.87E+34    |
| 312.4-0.4 | S           | 4.69E-21 | 3.01  | 33.29        | 3          | 33.2         | 1.75E+34    |
| 315.4-2.3* | RCW 86     | S     | 4.18E-21 | 2.86       | 34.88      | 2.7          | 33.0        | 1.54E+34  |
| 315.4-0.3 | ?           | 3.86E-21 | 7.02  | 36.03        | 7          | 35.9         | 1.69E+34    |
| 315.9-0.0 | S           | 3.44E-22 | 9.96  | 54.18        | 10         | 54.4         | 3.46E+33    |
| 316.3-0.0 | MSH14-57    | S     | 7.41E-21 | 4.72       | 27.66      | 4.7          | 27.5        | 1.91E+34  |
| 317.3-0.2 | S           | 5.85E-21 | 9.51  | 30.45        | 9.5        | 30.4         | 1.83E+34    |
| l,b       | Name   | Type | Σ     | $d_{\Sigma-D}$ | $D_{\Sigma-D}$ | $d_{ado}$ | $D_{ado}$ | L      |
|-----------|--------|------|--------|----------------|----------------|-----------|-----------|--------|
| 318.2+0.1 | S      | >4.19E-22 | ?     | <52.42         | 4              |           |           |        |
| 318.9+0.4 | C      | 1.43E-21  | 7.16  | 42.69          | 7.2            | 42.9      | 8.96E+33  |
| 320.4+1.2 | RCW 89 | C(P)  | 7.37E-21 | 2.72        | 27.72          | 4.2        | 42.8      | 4.58E+34 |
| 320.6+1.6 | S      | ?     | ?     | ?             | ?              |           |           |        |
| 330.0+15.0| Lupus L. | S   | 1.63E-21 | 0.80     | 41.8           | 0.8        | 41.9      | 9.69E+33 |
| 330.7+0.5 | S      | 6.45E-21 | 8.52  | 29.26          | 8.5            | 29.2      | 1.87E+34  |
| 330.9+0.1 | CTB 33 | S     | 8.36E-21 | 14.96    | 26.34          | 7.5        | 26.1      | 1.95E+34 |
| 331.3+1.1 | Kes 40 | S     | 1.34E-20 | 5.58     | 21.78          | 5.6        | 21.9      | 2.17E+34 |
| 331.8+0.1 | Kes 41 | S     | 5.02E-20 | 5.99     | 12.75          | 8          | 17.1      | 4.98E+34 |
| 332.4+0.1 | Kes 32 | S(D)  | 1.74E-20 | 4.48     | 19.58          | 4          | 17.5      | 1.80E+34 |
| 333.9+0.4 | S      | 5.46E-21 | 5.12  | 31.3           | 5.1            | 31.1      | 1.80E+34  |
| 334.0+0.5 | S      | 6.45E-21 | 8.52  | 29.26          | 8.5            | 29.2      | 1.87E+34  |
| 337.0+0.5 | CTB 33 | S     | 8.36E-21 | 14.96    | 26.34          | 12         | 21.1      | 1.25E+34 |
| 337.3+1.0 | Kes 40 | S     | 1.34E-20 | 5.58     | 21.78          | 5.6        | 21.9      | 2.17E+34 |
| 338.1+0.1 | S      | 2.68E-21 | 8.81  | 38.47          | 8.8            | 38.4      | 1.34E+34  |
| 338.3+0.0 | S      | 1.65E-20 | 6.65  | 20.03          | 8.6            | 19.9      | 2.24E+34  |
| 338.5+0.1 | S      | 2.23E-20 | 6.79  | 17.71          | 6.8            | 17.7      | 2.40E+34  |
| 340.4+0.4 | S      | 1.08E-20 | 9.75  | 23.8           | 9.7            | 23.7      | 2.03E+34  |
| 340.6+0.3 | S      | 2.09E-20 | 10.33 | 18.18          | 10.3           | 18.1      | 2.29E+34  |
| 341.2+0.9 | C(P)   | 6.41E-22 | 8.94  | 48.83          | 6.8            | 37.1      | 3.00E+33  |
| 341.9-0.3 | S      | 7.68E-21 | 13.35 | 27.27          | 13.3           | 27.2      | 1.91E+34  |
| l,b       | Name    | Type | Σ   | d_{Σ-D} | D_{Σ-D} | d_{ado} | D_{ado} | L       |
|----------|---------|------|-----|---------|---------|---------|---------|---------|
| 342.0-0.2| S       | 4.88E-21 | 10.82 | 32.77 | 10.8 | 32.7 | 1.76E+34 |
| 342.1+0.9| S       | 8.36E-22 | 16.91 | 46.71 | 16.9 | 46.7 | 6.17E+33 |
| 343.0-0.0| S       | ?     | ?    | ?      | ?    | ?    | ?       |
| 343.1-2.3| C?      | 1.18E-21 | 4.74 | 44.13 | 4.7 | 43.8 | 7.64E+33 |
| 343.1-0.7| S       | 2.07E-21 | 5.80 | 40.15 | 5.8 | 40.2 | 1.13E+34 |
| 344.7-0.1| C?      | 3.76E-21 | 12.51 | 36.4 | 12.5 | 36.4 | 1.69E+34 |
| 345.7-0.2| S       | 2.51E-21 | 22.09 | 38.89 | 18 | 31.7 | 8.40E+33 |
| 346.6-0.2| S       | 1.88E-20 | 8.19 | 18.97 | 8.2 | 19.0 | 2.33E+34 |
| 347.3-0.5| S?      | ?     | ?    | ?      | ?    | ?    | 6.0     |
| 348.5-0.0| S       | 1.51E-20 | 7.14 | 20.77 | 7.1 | 20.7 | 2.18E+34 |
| 348.5+0.1| CTB 37A | 4.82E-20 | 2.97 | 12.97 | 6.0 | 26.2 | 1.12E+35 |
| 348.7+0.3| CTB 37B | 1.35E-20 | 4.38 | 21.67 | 7.0 | 34.5 | 5.52E+34 |
| 349.2-0.1| S       | 3.90E-21 | 16.85 | 35.87 | 16 | 34.1 | 1.55E+34 |
| 349.7+0.2| S       | 6.02E-19 | 6.75 | 4.66 | 12.0 | 8.2 | 1.24E+35 |
| 350.0-2.0| S       | 1.93E-21 | 3.10 | 40.62 | 3.1 | 40.6 | 1.08E+34 |
| 351.2+0.1| C?      | 1.54E-20 | 10.08 | 20.6 | 10.1 | 20.6 | 2.20E+34 |
| 351.7+0.8| S       | 5.97E-21 | 6.54 | 30.19 | 6.5 | 30.0 | 1.83E+34 |
| 351.9-0.9| S       | 2.51E-21 | 12.83 | 38.89 | 12.8 | 38.8 | 1.27E+34 |
| 352.7-0.1| S       | 1.25E-20 | 11.10 | 22.36 | 11 | 22.1 | 2.09E+34 |
| 353.9-2.0| S       | 8.91E-22 | 12.22 | 46.22 | 12 | 45.4 | 6.23E+33 |
| 354.1+0.1| C?      | ?     | ?    | ?      | ?    | ?    | ?       |
| 354.8-0.8| S       | 1.17E-21 | 8.00 | 44.18 | 8 | 44.2 | 7.75E+33 |
| 355.6-0.0| S       | 9.41E-21 | 12.48 | 25.12 | 12 | 24.2 | 1.87E+34 |
| 355.9-2.5| S       | 7.12E-21 | 7.43 | 28.11 | 7.4 | 28.0 | 1.89E+34 |
| 356.2+4.5| S       | 9.63E-22 | 6.27 | 45.62 | 6 | 43.6 | 6.23E+33 |
| 356.3-0.3| S       | 5.86E-21 | 11.88 | 30.41 | 11.8 | 30.2 | 1.81E+34 |
| 356.3-1.5| S       | 1.51E-21 | 8.40 | 42.35 | 8.4 | 42.3 | 9.15E+33 |
| 357.7-0.1| MSH 17-39 | ?      | 2.32E-19 | 4.82 | 6.86 | 7.0 | 9.9 | 7.85E+34 |
| 357.7+0.3| S       | 2.61E-21 | 5.53 | 38.62 | 5.5 | 38.4 | 1.31E+34 |
| 358.0+3.8| S       | 1.56E-22 | 5.59 | 61.8 | 5.2 | 57.5 | 1.75E+33 |
| 359.0-0.9| S       | 6.54E-21 | 4.35 | 29.09 | 4.4 | 29.4 | 1.92E+34 |
| 359.1-0.5| S       | 3.66E-21 | 5.23 | 36.51 | 5.2 | 36.3 | 1.64E+34 |
| 359.1+0.9| S       | 5.70E-21 | 9.19 | 30.76 | 9.2 | 30.8 | 1.83E+34 |
