Turk J Phy
24 (2000) , 531 – 542.

Associations of X-ray Binaries with Open Clusters and Supernova Remnants

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Received 07.07.1999

Abstract

Searching for X-ray binaries projected on open clusters (OCs) and supernova remnants (SNRs), associations of X-ray binaries with OCs and SNRs in the Galaxy are discussed. Three of the high mass X-ray binaries (HMXBs) and four of the low mass X-ray binaries (LMXBs) are projected on open clusters. Five of HMXBs and six of LMXBs are projected on SNRs. The number of the HMXB projections are less than the LMXBs, which is not expected and is surprising since the objects in this study, except the LMXBs, are all young objects. Such associations help us improve distance and age estimates of these objects and understand their origins. We discuss the associations of HMXB 0146+612 with OC NGC 663, HMXB 0749–600 with OC NGC 2516 and LMXB 2259+587 with SNR G109.1–1.0 (CTB 109), and conclude that they may likely be real. We also discuss the interesting associations of SNR G39.7–2.0 (W50) with HMXB 1909+048 (SS433) and association of LMXB 1724–307 with globular cluster Terzan 2 and with OC vdB 228. Other associations are found are to be unreliable.

Keywords X-ray binaries, open clusters, supernova remnants.

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1. Introduction

After the first discovery of the strongest X-ray source, Sco X–1, by a rocket experiment, Giocconi *et al.*[1] were the first to point out that the bright X-ray sources must be accreating neutron stars or black holes in close binary systems [2]. Main properties of binary X-ray sources, in order to make identifications with optical components, were discussed first by Guseinov [3]. In the middle 1970's, there was an opinion that all X-ray binaries in the Galaxy might have luminosities between 10^{36} and 10^{38} $\mathrm{erg \cdot s^{-1}}$, fluxes > 20 μJy and generally supergiant optical components [4]. Gursky and Shreier [5] suggested that all sources with fluxes < 20 μJy are extragalactic. van den Heuvel [6] divided these sources into two groups with supergiant companions, high mass X-ray binaries (HMXB), and with companions of $2M_{\odot}$, low mass X-ray binaries (LMXB).

The transient sources, Cen X-2 [7], Cen X-4 [8], 1543–475, and 1735–28 [9, 10], were known until 1974 without any simple model to understand this phenomena. On the other hand, examinations of the second and third Uhuru catalog [10, 11], for nonidentified point sources with fluxes < 20 μJy [12, 13] show that some of them must belong to the Galaxy. Amnuel *et al.*[12] also show that in the $2 - 6$ keV band there are $\leq 10^4$ sources in the Galaxy whose luminosity $> 10^{33}$ $\mathrm{erg \cdot s^{-1}}$. Their luminosity may increase to 10^{38} $\mathrm{erg \cdot s^{-1}}$ as a result of different type of processes, among which are novae (transient) properties, with a typical light curve. Among the 73 HMXBs excluding 9 which are in Magellan Clouds [14], 25 of the HMXBs were known in 1973. Among these sources, eight of them; B0053+604, B01427+612, B0535+262, B0726–260, B1118–615, B1807–10, B1845–024 and B2206+543 have fluxes < 20 μJy. 53 LMXBs out of 123 that are known today, were known before 1973. Two sources B0656–072 and B0918–549 have fluxes < 20 μJy. Therefore, a large number of X-ray binaries considered as massive may in reality prove themselves to be LMXBs. Of course, the angular resolution and sensitivity of the observational devices were not good in early days. Improvements in these areas have increased the number of sources and their fluxes. Some of the sources in the galactic center direction have been recognized to be more than one located very close to each other by the result of small angular resolutions in early days, now sources known in the galactic center increase and lie very close to each other. Therefore, without enough X-ray and optical data, it is difficult to divide sources into different groups. For this reason, associations of X-ray sources, considered as LMXBs with open clusters (OCs) are not surprising. General properties and differences of these two groups are discussed in van Paradijs and Mc Clintock [15].

We discuss the possible associations of X-ray binaries with OCs in §2. In §3 the associations of X-ray binaries with supernova remnants are presented. The conclusion is given in §4.

2. Associations of X-ray sources with open clusters

Amnuel *et al.*[12, 13] mentioned that most of the transient sources occur with an optical component of $1 - 2\,M_{\odot}$ but van Paradijs [14] and van Paradijs and Mc Clintock [15] give $\geq 5M_{\odot}$. The difference in masses are connected with supposed ranges of mass ratio distribution chances of the components in binary systems. According to the initial mass function [16, 17, 18, 19], the number of small mass stars increase sharply, therefore the number density of pairs with initially small mass ratio remains large, even with their easy distruption after the supernovae explosion. Today, it is known that O stars and early type B stars often consist in binary systems of components having similar masses, $M_1/M_2 = 1 - 0.5\ M_\odot$ [20] There are examples of binary systems in which the stars are massive or with equal masses (see data of HD50820, and HD208816–VV Cep and many others). Also there are small mass close binary systems where both components with equal masses that leave the main sequence (HD41040, 64 Ori A and HD199532, and α Oct). We must therefore be optimistic to increase the possibility of the associations of the HMXBs with the SNRs. We do not exclude the possibility of LMXB-SNR associations since they may appear in the result of accretion induced collapses.

We search for associations of X-ray binaries with SNRs and OCs, which include stars with equal ages and common origins. The associations may therefore give us more definite information about the X-ray sources, i.e. their improved distances and age estimates, and their origins.

For the possible projections and real pairs of SNR–X-ray binary and OC–X-ray binary, and distances of objects in each pair are examined and discussed. We use the catalogs of X-ray binaries with 194 sources [14], OCs with 1110 clusters [21] and SNRs with 182 remnants [22]. Three of the high mass X-ray binaries and four of the low mass X-ray binaries are projected on OCs. Five of the high mass X-ray binaries and six of the low mass X-ray binaries are projected on SNRs. The properties of the OCs and SNRs are presented in Table 1, and the X-ray binaries are presented in Table 2.

Dividing X-ray sources into two with respect to their components, high mass and low mass, we search for their associations with OCs. To have reliable (real) associations, it is necessary that an X-ray source be projected on an OC and indepentently estimated distances and ages of both objects should be close enough (within limits of error). ¿From a comparison of interstellar absorbsion (A_v), hydrogen column density ($N_{\rm H}$) and visible magnitude (m_v) with possible absolute magnitude (M_v) for a suitable spectral type of the compenion stars (Sp) of the each association pair, give us clues to check the corresponding distances for each pair independently. Moreover, the A_v values that are calculated using $R = A_v/E(B-V) = 3.2$ [23] $E(B-V)$ are taken form van Paradijs and Mc Clintock [15] and Lyngå [21].

According to today's point of view, LMXBs belong to old population in the Galaxy, their associations with OCs cannot, therefore, be real. There are four LMXBs OC pairs, which look likely to be true since, unlike HMXBs, the angular separations of LMXBs are remarkablely small and projections in Table 4 are better than HMXBs. Currently data about the objects are very poor. We discuss the pairs in Table 3 below.

HMXB 0146+612– NGC 663: This high mass X-ray binary has been situated in NGC 663 by Mac Connell and Coyne [24] and Hellier [25]. The distance to NGC 663 is very close to the Sun, 2.8 kpc [21] and 2.5 kpc [26]. The X-ray binary has an optical

Table 1. Properties of the SNRs and the OCs

Name	A_v	$N_{\rm H}(10^{21})$	$d(kpc)$	$\theta(')$	$\log(\tau)$
NGC 663	2.9[a]		2.5-2.8	16,15[a]	7.35
NGC 2516	0.4		0.43–0.44	29,22[a]	8.03–8.15
IC 1396	1.6		0.8	50	6.0–6.8
Rup 115				5.0	
NGC 6134	1.5		0.8	6.0-7.[a]	8.8
vdB 228				1.5	
NGC 641	1		0.8	18,15[a]	8.5
G126.2+1.6	1.4-1.8[b]	6–2[b]	2.5[c]	72	
G180.–1.7	0.7[d]	2.2–1.4[e]	1.0[f]	180	
G327.1–1.1		1–10[g]	8[f]	14	
G39.7–2.0	7[h]	10[i]	5[j]	60 × 120	
G0.0–0.0			8[k]	3	
G0.0–0.0			8[k]	3	
G45.7–0.4			6.5[f]	22	
G109.1–1.0	2.5[k]	4[l]	3[f]	28	

[a]Ahumada J. and Lapasset E., *Astron. Astrophys. Supp.*, **109** (1995), 375.
[b]Blair W. P., Kirshner R. P., Gull T. R., Sarger D. L., Parker R. A. R., *Astrophys. J.*, **242** (1980), 592.
[c]Joneas G., Roger R. S., Dewdney P. E., *Astron. Astrophys.*, **219** (1989), 303.
[d]Fesen R. A., Blair W. P. and Kirshner R. P., *Astrophys. J.*, **292** (1985), 29.
[e]Sauvaget J. L., Ballet J. and Rothflug R., *Astron. Astrophys.*, **227** (1990), 183.
[f]Allahkverdiev A. O., Anbay A., Guseinov O. H. and Tuncer E. (1995), *in preparetion.*
[g]Markert, T. H., Lamb R. C., Hartman R. C., Tompson D. J. and Bignami G. F., *Astrophys. J.*, **248** (1981), L17.
[h]Cherepashchuk A. M., Aslanov A. A., Kornilov V. G., *Soviet Astron.*, **26** (1982), 697.
[i]Band D. L., *Astrophys. J.*, **336** (1989), 937.
[j]Spencer R. E., *MNRAS*, **209** (1984), 869.
[k]Coe M. J., and Jones L. R., *MNRAS*, **259** (1992), 191.
[l]Morini M., Robba N. R., Smith A., van der Klis M., *Astrophys. J.*, **333** (1988), 777.

counterpart of B5IIIe spectral class with visible magnetude of 11.3^m. Their distances therefore may roughly coincide, only if we consider M_v about -4^m and A_v about 3^m. This association is likely to be real.

HMXB 0749–600– NGC 2516: According to Battinelli *et al.*[27] OC NGC 2516 has a distance of 0.43 kpc. The companion star of the X-ray binary is a B8IIIe star with M_v about -1^m, under such a distance the visual magnitude should be about 7.5^m but in reality it is 6.7^m. Considering the possible error in the distance and M_v alues, we may consider that these quanties are equal. Although the X-ray binary is not situated in the open cluster, they may have a relation. Of course, a young OC contains massive stars which may produce X-ray sources after their evolution. The kick velocity after a Supernova explosion is enough for them to escape from the OC, but in this case simple evaporation from OC is also possible. If we consider the galactic latitude of this object

($b = 16$), the association is more reliable.

HMXB 2138+568– IC 1396: In the direction of the X-ray source there is no other OC closer than 10°. The distance to the OC is well known, 0.8 kpc [27]. Koyama *et al.*[28] stated that the $N_{\rm H}$ and the mass of the possible optical component of the LMXB are 10^{22} cm^{-2} and $\sim 10 M_{\odot}$ respectively. They suppose that the component is a Be star. Since, a Be star has not been observed yet and the $N_{\rm H}$ is very large, this is not a reliable association.

LMXB 1624–490– NGC 6134: The $N_{\rm H}$ and A_v values for the LMXB are $5 \cdot 10^{22}$ cm^{-2} and 22^m respectively, which shows that the distance to the X-ray source is very large compared to the OC. The distance of the open cluster is 0.8 kpc. HD 148937 is about 1°.5 away from the OC. The A_v value, $\log N_{\rm HI}$ and the distance to HD 148937 are 2.2, 21.6 and 1.4 kpc respectively [29, 30]. The distance of the LMXB is therefore much larger than the OC. This projection has no chance of being a real assocation.

LMXB 1724–307– vdB 228: Among all sources, this is the best projection pair. The LMXB belongs to the globular cluster Terzan 2 ($\alpha_{1950} = 17^h 24^m 20^s.09$, $\delta_{1950} = -30°45'39''.4$). It is placed in the center of the globular cluster [14]. Barret *et al.*[31] observed a new hard X-ray radiation source from ($\alpha_{1950} = 17^h 24^m 14^s$, $\delta_{1950} = -30°44'14''$ mean error in the coordinates for GRANAT is $\geq 1'$ [32]). It has an identification with the LMXB. Considering that both emissions are coming form the known LMXB, then it is the only LMXB in a globular cluster with hard X-ray emission. The coordinate of the hard X-ray emission does not precisely coincide with the LMXB. Angular seperations between the hard X-ray source and the globular cluster, and the hard X-ray source and OC are $1'.3$ and $< 1'.3$ respectively. The hard X-ray source may therefore be associated with the OC.

LMXB 1741–322–NGC 6416: $N_{\rm H}$ for the LMXB shows that its distance cannot be closer than several kpc. The distance of the open cluster is 0.8 kpc. This association is not likely to be true.

3. Associations of X-ray sources with supernova remnants

For examination of possible projections and real pairs of SNR and binary X-ray sources, coordinates of 182 SNR [22] and coordinates of 125 LMXBs and 69 HMXBs [14] are compared. The results are presented in Table 4. There are five HMXB and six LMXB projections on SNRs. The number density of LMXBs per unit degree square increases sharply in the direction of the galactic center. For this reason, there are two projections on Sag A which has a small angular size. We discuss the possible projection pairs in Table 4 below. The distances of the SNRs are taken from Allakhverdiev *et al.*[33].

For an X-ray source observed to be bright, it is necessary that the binary system, that it is found in fill its Roche lobe (for close binary systems) or should have strong stellar wind (HMXBs). The time for this process increases with decreasing mass of the secondary component and delay may be up to 10^{10} yrs for LMXBs. As lifetimes of the SNRs are

Table 2. Properties of the X-ray binaries

Name	A_v	$N_{\rm H}(10^{21})$	$d(kpc)$	Type	Sp	m_v
H 0146.9+6121		5^a			B5IIIe	11.3
H 0749–600	0.3				B8IIIe	6.7
H 2138+568		7-$10^{b,c}$	$> 1^c$	Tr/Pul		
L 1608–522	$\sim 6^d$	16^e	4-7	Tr/Bur		~ 19
L 1624–490	22	50^f		Bur		
L 1724–307	3–4^g	7^g	$\sim 10^h$	Bur		
L 1741–322		50		Tr		
H 0115+634	$\geq 5^d$	12^i	3^j-$(3.5\text{-}4)^k$	Tr/Pul	OBe	15.9
H 0535+262	2.6 ^{d}	$1.8-2.4$	1.8^j-2.0^d	Tr/Pul	Be–O9.7IIe	9.3
H 1555–552					B2e	8.6
H 1909+048	7^g	6.2^g	3.2^j-5^d		SGO–Bp	14.2
L 1742.5–2859		60^l				
L 1742–289	$\sim 1.2^d$	$\sim 100^o$	1.2^d	Tr/Bar?	K3V	18.2
L 1915+105	20	50^j	8	Tr?	RedIII	23
L 2259+587	$\sim 3^d$	3.6	4^p	Pul		> 22.6

[a] Hellier, C., *MNRAS*, **271** (1994), L21.
[b] Koyama K., Kawada, M. and Tawara, Y., *Astrophys. J.*, **366** (1991), L19.
[c] Schulz N. S., Kahabka P. and Zinnecer H., *Astron. Astrophys.*, **295** (1995), 413.
[d] Bradt H. V. D. and Mc Clintock J. E., *Ann. Rev. Astron. Astrophys.*, **21** (1983), 13.
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[g] Grindlay J. E., Band D., Seward F., Leahy D., Weisskopf M. C. and Marshall F. E., *Astrophys. J.*, **277** (1984), 286.
[h] Joneas G., Roger R. S., Dewdney P. E., *Astron. Astrophys.*, **219** (1989), 303.
[i] Nagase F., Donati T., Tanaka Y., Makishima K., Mihara T., Sakao T., Tsunemi H., Kitamoto S., Tamura K., Yoshida A. and Nakamura H., *Astrophys. J.*, **375** (1991), L49.
[j] van Oijen J. G. J., *Astron. Astrophys.*, **217** (1989), 115.
[k] Tamura K., Tsunemi H., Kitamoto S., and Hayashida K., *Astrophys. J.*, **389** (1992), 676.
[l] Morini M., Robba N. R., Smith A., van der Klis M., *Astrophys. J.*, **333** (1988), 777.
[o] Watson M. G., Willingate R., Grindlay J. E. and Hertz P., *Astrophys. J.*, **250** (1981), 142.
[p] Davies S. R., and Coe M. J., *MNRAS*, **249** (1991), 313.

Table 3. Projection of X-ray sources on OCs

Name X–ray source	α_{1950} ($^{h\ m\ s}$)	δ_{1950} ($^{\circ\ \prime\ \prime\prime}$)	Name OC	α_{1950} ($^{h\ m\ s}$)	δ_{1950} ($^{\circ\ \prime\ \prime\prime}$)	$\Delta\xi$ ($'$)
H 0146.9+6121	01 43 32.6	+61 06 26	NGC 663	01 42.6	+61 00	9.4
H 0749–600	07 55 27.7	–60 57 54	NGC 2516	07 57.5	–60 44	20
H 2138+568	21 38.0	+56 50	IC 1396	21 37.5	+57 16	26
L 1608–522	16 08 52.2	–52 17 43	Rup 115	16 09.0	–52 15	3
L 1624–490	16 24 17.8	–49 04 46	NGC 6134	16 24.0	–49 02	4
L 1724–307	17 24 20.1	–30 45 39	vdB 228	17 24.3	–30 45	0.8
L 1741–322	17 41 46.	–32 13 25	NGC 6416	17 41.1	–32 20	11

not more than 10^5 yrs, we may therefore expect associations of the SNRs with the X-ray sources that are massive, close binary systems with initial mass ratio of components are very close to 1. The associations of the SNRs with the LMXBs may be in the result of SN explosions due to the accretion induced collapses, but these events are rare. It is also less probable to survive after the assymetric SN explosion.

In most of the projection pairs in Table 4, data of A_v, N_H and distance to X-ray source and SNR pairs have large discripances. Only for pairs SNR G39.7-2.0 and HMXB 1909+048, SNR G109.1-1.0 and LMXB 2259+587 have good distance agreements. For LMXB 1742-289, it has a contradiction between the optical information (A_v, d) and N_H for the X-ray source. This contradiction leads to a doubt about the correct identification. For all the pairs except the ones mentioned above, tangential velocities of the X-ray sources, estimated from the distances and the angular seperations between the sources and the center of the SNRs, are more than 700 $km\ s^{-1}$. This quantity is very large if compared with the maximum value for the orbital velocities in close binary systems and center of mass velocities for known X-ray binaries. Even if we take into account the possible errors under the estimated velocities, the projections become by chance. In addition to these, we remind that SNRs G5.4-1.2 and G343.1-2.3 are probably connected to the radio pulsars PSR 1757-24 and 1706-447, respectively. Moreover, of course the SNR G263.9-3.3 and Vela pulsars are, indeed, related with each other [34].

HMXB 1909+048–SNR G39.7–2.0: This HMXB is the famous X-ray source SS433 which is the first X-ray source found in a SNR. SNR W50 is an old asymetrical shell which is located in a cloudy interstellar medium. It is the second most elongated SNR ($b/a = 0.5$), the first one is SNR 3C58 according to Shaver [35] and the first most elonged SNR according to Green [22].

HMXB has an observed plasma jet of about 0.1 c [36] and shell of the SNR W50 extends in the direction of the jet. What are the effects of the HMXB and its jet on the influence of the SNR shell? Major axis of SNR W50 coincides with the direction of small-scale radio jet, large-scale X-ray and optical emissions [37]. Same events are also observed in optical and X-ray band [38]. X-ray and radio luminosity of SNR W50 are one order higher than one expects from a similiar SNR with the same age and size. The central region of W50 has a spectral index of $-0.6 \leq \alpha \leq -0.5$. Its radio band "ears" have an α of $-(0.6–0.7)$ which is slightly large. Kovalenko *et al.*[39] give an α of -0.5 ± 0.1 for the entire SNR and notes that there is a low-frequency cut-off in the radio spectrum. There is no doubt about the "ears" which are blown out by the material from HMXB SS433. We observe the influences of SS433 on the luminosity of W50 but not on the α in the radio band.

The distance to SS433 is 4.9 ± 0.2 [40] and 5.0 ± 0.5 kpc [41] while the model fits to the optical and radio observations of the jet patterns. Distance estimate from the HI measurements shows that the SNR W50 is $3 - 3.5$ kpc [42] away from the Sun. We believe that the distance of the HMXB is true and the assocation is likely be true from the above discussion, we therefore adopt 5 kpc to SNR W50. Moreover, if the HMXB

Table 4. Projection of X-ray sources on SNRs

Name X–ray source	α_{1950} ($^{h\ m\ s}$)	δ_{1950} ($^{\circ\ \prime\ \prime\prime}$)	Name SNR	α_{1950} ($^{h\ m\ s}$)	δ_{1950} ($^{\circ\ \prime\ \prime\prime}$)	$\Delta\xi$ ($'$)
H 0115+634	01 15 13.8	+63 28 38	G126.2+1.6	01 18 30	+64 00	38
H 0535+262	05 35 48.0	+26 17 18	G180.–1.7	05 36 00	+27 50	92
H 0834–430	08 34 10.1	–43 00 36	G263.9–3.3	08 32 30	–45 35	155
H 1555–552	15 50 26.4	–55 10 54	G327.1–1.1	15 50 30	–55 00	11
H 1909+048	19 09 21.2	+04 53 54	G39.7–2.0	19 10 00	+04 50	10
L 1705–440	17 05 17.9	–44 02 13	G343.1–2.3	17 04 30	–44 15	15
L 1742.5–2859	17 42 30.0	–28 59 01	G0.0–0.0	17 42 33	–28 59	0.7
L 1742–289	17 42 26.3	–28 59 57	G0.0–0.0	17 42 33	–28 59	1.7
L 1758–250	17 58 03.1	–25 04 43	G5.4–1.2	17 59 00	–24 55	16
L 1915+105	19 12 55	+10 52 40	G45.7–0.4	19 14.05	+11.04	19
L 2259+587	22 59 02.6	+58 36 38	G109.1–1.0	22 59 30	+58 37	4

has a connection with the SNR, then these binary system should have components with almost the same masses (intial masses on the main sequence), since the lifetime of a SNR is neglegable even compared with the lifetime of a massive star.

There is a known Be star in the binary system with radio pulsar 1259–63 [43, 44]. The characteristic age of the pulsar is 5.2 yrs, about 2–3 times larger than possible age for a SNR. Their rotational energy loss, ($\dot{E}$), is $\dot{E} >\sim 8 \cdot 10^{35}$ erg$\cdot$s^{-1}, but radio luminosity and magnetic field activities are small. It is also difficult to discover a neutron star with a high magnetic field in a close binary system. The magnetic field makes it difficult to accreate matter in binary systems. Most of the radio pulsars, even at their birth, have very small luminosity, which limits their observation out to $1-2$ kpc. We therefore believe that there exist large numbers of binary systems with very close component masses [20] and accreation of matter on very young NSs.

LMXB 2259+587–SNR G109.1–1.0: The LMXB is just on the SNR G109.1–1.0 (CTB 109) [45, 46]. Huang and Thaddeus [47] discussed the probable associations of CTB 109 with *OB* association, Cep OB1, which is now believed to lie at a distance 2.8 kpc [48], instead of the distance adopted by Humpreys [49] which was 3.5 kpc. We adopt the distance to this object at 3 kpc. CTB 109 has an average speactral index, α, of –0.57 [37], –0.5 [22], and –0.48, which does not change in a band between 10 MHz and 326 Hz [39]. Inside the shell, the α value is steeper ($-(0.5-0.7)$) than in the rim (~ -0.4) [37]. In radio band, only half of the shell is observed. In $0.5-4$ keV band, the total flux of the X-ray source is about 1 μJy. Its luminosity does not exceed $5 \cdot 10^{34}$ erg $\cdot$ s^{-1} under the distance 3 kpc. In addition, it shows pulsar phenomena, therefore, it is an extraordinary LMXB. Presence of an X-ray jet which is powered by the central point source also does not show considerable influence on the SNR whose X-ray radiation in the $0.5-4$ keV band is 5 times larger [50, 51]. The spectral endex of the radiation in the radio band of the SNR is typical for shell type SNRs (as in the W50 case).

Yet, no optical counterpart has been found for an X-ray pulsar with $m_v < 22.6$ [52, 53] and orbital period [14]. The size of CTB 109 is not smaller than $28'$, and the deviation of the X-ray source from the geometic center of the SNR is small, $7'$. Therefore, in order to talk about the association, their distances should coincide. The $N_{\rm H}$ values are nearly the same for the both of the objects. The $N_{\rm H}$ value of the SNR is about $4 \cdot 10^{21}$ cm^{-2} and the $N_{\rm H}$ estimated for the LMXB from the X-ray spectrum is $3 \cdot 10^{21}$ cm^{-2}. Their distances may therefore coincide. Interstellar absorbsion for CTB 109 and for LMXB 2259+587 are also similiar (see Table 1 and 2). If this is a true association then we may have a remarkable case with an accreation induced collapse with a small mass optical component. We cannot avoid the optical component to explain total X-ray luminosity of the pulsar since the pulse period is 6.98 s and consequently total rotational energy loss for a single pulsar cannot explain the registered luminosity if we also take into account the uncertainty in the distance.

Cir X-1 (LMXB 1516–569) also has a possible jet [54] and it does not have a projection on a SNR. The closest SNR is SNR G321.9–0.3 with angular diameter $25'$. The angular distance between them is about $20'$. A binary system with a jet creates a synchotron nebula with size $\sim 10' \times 5'$ and runs away from the SNR [55]. The distance of Cir X-1 is 8 kpc [55] and larger than 6 kpc [56], and the $N_{\rm H}$ value is $4 \cdot 10^{22}$ cm^{-2}. The distance of the SNR is about 5 kpc [33]. Distance of Cir X-1 may also be 5 kpc, if we take into account their position in the galactic plane ($l = 322^{\circ}.1$, $b = 0^{\circ}$) where there is a dense interstellar medium. Considering that they are associated at 5 kpc, Cir X-1 should have a tangential velocity of > 1500 km $\cdot$ s^{-1}. This velocity is very large to keep any binary system together, therefore this association is not likely to be true.

Schwentker [57] discovered a new X-ray pulsar which is associated with a new SNR G22.8+1.5. The pulse period (P) of the pulsar is 5.45 s which is very similiar to LMXB 2259-587 ($P = 6.98$ s). The α_{radio} of the SNR is -0.39 ± 0.08 (a little bit flatter than CTB 109). As the SNR G22.8+1.5 has a bigger angular size and was discovered under a special search, it must be an old SNR. The distance estimate for the SNR is $1.4 - 3.9$ kpc [57]. The source is located just behind the OB association SCT OB2 with the distance of ~ 1 kpc.

4. Conclusions

Possible associations of X-ray binaries with OCs and SNRs are investigated. Comparing the properties of galactic objects independently provide a better tool for their relations and physical properties *i.e.* age and distance. Three among 73 HXRBs and four among 123 LXRBs are projected on OCs. However, associations of HMXB 0146+612 with NGC 663 and HMXB 0749-600–NGC 2516 are the most reliable pairs among the studied cases. Moreover, association of LMXB 1724-307–vdB 228 pair may also have relations due to the hard X-ray emission. Five HMXBs and six LXRBs are projected on SNRs. Only, two of the pairs, HMXB 1909+048–SNR G39.7-2.0 and LMXB 2259+587–SNR G109.1-1.0, have potential reliable relations. We also discuss the interesting associations of LMXB 1724-307 with globular cluster Terzan 2 and with OC vbB 228. The reliable associations between different galactic objects increase the knowledge about their structure and origin. Moreover, the distance to sky objects can be estimated more accurately.

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