Jets at all Scales
Proceedings IAU Symposium No. 275, 2011
G. E. Romero, R. A. Sunyaev & T. Belloni, eds.

doi:10.1017/S1743921310016340

On the apparent lack of Be X-ray binaries with black holes in the galaxy and in the Magellanic Clouds

Janusz Ziółkowski[1] and Krzysztof Belczyński[2]

[1]Copernicus Astronomical Center, ul. Bartycka 18, 00-716 Warsaw, Poland
email: jz@camk.edu.pl

[2]Los Alamos National Lab, P.O. Box 1663, MS 466, Los Alamos, NM 87545
email: kbelczyn@nmsu.edu

Abstract. In the Galaxy there are 67 Be X-ray binaries known to-date. Out of those, 45 host a neutron star, and for the reminder the nature of a companion is not known. None, so far, is known to host a black hole. This disparity is referred to as a missing Be – black hole X-ray binary problem. The stellar population synthesis calculations following the formation of Be X-ray binaries (Belczyński & Ziółkowski 2009) predict that the ratio of the binaries with neutron stars to the ones with black holes is rather high $F_{\rm NS/BH} \sim 30-50$. A comparison of this ratio with the number of confirmed Be – neutron star X-ray binaries (45) indicates that the expected number of Be – black hole X-ray binaries is of the order of only $\sim 0-2$. This is entirely consistent with the observed Galactic sample. Therefore, there is no problem of the missing Be+BH X-Ray Binaries for the Galaxy

In the Magellanic Clouds there are 94 Be X-ray binaries known to-date. Out of those, 60 host a neutron star. Again, none hosts a black hole. The stellar population synthesis calculations carried out specifically for the Magellanic Clouds (Ziółkowski & Belczyński 2010) predict that the ratio of the Be X-ray binaries with neutron stars to the ones with black holes is only $F_{\rm NS/BH} \sim 10$. This value is rather too low, as it implies the expected number of Be+BH X-ray binaries of the order of ~ 6, while none is observed. We found, that to remove the discrepancy, one has to take into account a different history of the star formation rate in the Magellanic Clouds, with the respect to the Galaxy. New stellar population synthesis calculations are currently being carried out.

Keywords. black holes: binaries, X-rays: binaries, (stars:) binaries: close, stars: evolution, stars: neutron, emission-line, Be

1. Introduction

Be X-ray binaries (Be XRBs) are the most numerous subclass of high mass X-ray binaries. The description of the properties of these systems is given, e.g. in Negueruela *et al.* 2001, Ziółkowski 2002, Belczyński & Ziółkowski 2009 and references therein.

In this work we study the origins of the apparent disparity of number of known Be XRBs with neutron stars (NSs) (105) as compared to no known Be XRBs with black holes (BHs) in Galaxy and in the Magellanic Clouds. This disparity is referred to as a missing Be – black hole X-ray binary problem.

2. Stellar Population Synthesis (SPS) Calculations

We evolve a Galactic population of massive binaries using `StarTrack` stellar population synthesis code (Belczyński *et al.* 2008). We adopt solar metallicity ($Z = 0.02$) for the

Galactic population and low metallicity ($Z = 0.008$) for the Magellanic Clouds. During our SPS calculations, we consider any system a Be X-ray binary if: *(i)* it hosts either a NS or a BH accretor; *(ii)* donor is a main sequence star (burning H in its core); *(iii)* donor mass is higher than 3 $M_\odot$ (O/B star); *(iv)* orbital period is in the range $10 \leqslant P_{\rm orb} \leqslant 300$ day; and *(v)* only a fraction $F_{\rm Be} = 0.25$ of the above systems are designated as hosting a Be star and not a regular O/B star.

3. Galaxy

In the Galaxy there are 67 Be X-ray binaries known to-date. Out of those, 45 host a neutron star, and for the reminder the nature of a companion is not known. None, so far, is known to host a black hole. The stellar population synthesis calculations following the formation of Be X-ray binaries (Belczyński & Ziółkowski 2009) predict that the ratio of the binaries with neutron stars to the ones with black holes is rather high $F_{\rm NS/BH} \sim 30-50$. A comparison of this ratio with the number of confirmed Be – neutron star X-ray binaries (45) indicates that the expected number of Be – black hole X-ray binaries is of the order of only $\sim 0-2$. This is entirely consistent with the observed Galactic sample. Therefore, there is no problem of the missing Be+BH X-Ray Binaries for the Galaxy

4. Magellanic Clouds

In the Magellanic Clouds there are 94 Be X-ray binaries known to-date. Out of those, 60 host a neutron star. Again, none hosts a black hole. The stellar population synthesis calculations carried out specifically for the Magellanic Clouds (Ziółkowski &Belczyński 2010) predict that the ratio of the Be X-ray binaries with neutron stars to the ones with black holes is only $F_{\rm NS/BH} \sim 10$. This value is rather too low, as it implies the expected number of Be+BH X-ray binaries of the order of ~ 6, while none is observed. We found, that to remove the discrepancy, one has to take into account a different history of the star formation rate in the Magellanic Clouds, with the respect to the Galaxy. Magellanic Clouds are in many ways very different from the Galaxy when comparing the population of XRBs. Let us compare the numbers for three classes of XRBs:

(1) Be XRBs: 67 in the Galaxy vs 94 in the Magellanic Clouds
(2) other High Mass XRBs: 42 vs 10
(3) Low Mass XRBs: 197 vs 2

It is obvious that formation of stars in Magellanic Clouds had to proceed in a completely different way from that in the Galaxy. We are currently carrying out the new stellar population synthesis calculations trying to take into account this fact.

References

Belczyński, K., Kalogera, V., Rasio, F. A., Taam, R. E., Zezas, A., Bulik, T., Maccarone, T. J., & Ivanova, N. 2008, *ApJ Suppl* 174, 223

Belczyński, K. & Ziolkowski, J. 2009, *ApJ* 707, 870

Negueruela, I., Okazaki, A. T., Fabregat, J., Coe, M. J., Munari, U. & Tomov, T. 2001, *A&A* 369, 117

Ziółkowski, J. 2002, *Mem. Soc. Astron. Ital.* 73, 1038

Ziolkowski, J. & Belczyński, K. 2010, *in preparation*