Erratum: Population synthesis on high-mass X-ray binaries: prospects and constraints from the universal X-ray luminosity function

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This is an erratum to the paper entitled ‘Population synthesis on high-mass X-ray binaries: prospects and constraints from the universal X-ray luminosity function’, published in MNRAS, 437, 1187 (2014). An error in the assumption of the initial mass function (IMF) and adopted mass range caused the normalization of the X-ray luminosity function (XLF) in the original paper to be calculated wrongly. Due to a misunderstanding, we choose the IMF of Kroupa (2001, KROUPA01 for short) and set the mass range as 5.0 M⊙ ∞ for the normalization, while the correct normalization is Salpeter IMF and mass range of 0.1–100 M⊙, which is used by Mineo, Gilfanov & Sunyaev (2012) to derive the observed average XLF.

Although this introduces a major difference in the resulting normalization of a factor of ~3 (see the appendix), the results and basic conclusions of the paper remain largely unchanged. The observed average XLF can still be reconstructed pretty well by slightly adjusting several parameters within the range of reasonable value. The general feature in Fig. 7 has no/negligible change.

In more detail, the parameter combination in the basic model now is chosen as ‘SFH = 50 Myr, α = 0, αCE = 0.5, ηEdd = 100, f = 0.5, σkick = 110 km s⁻¹ and the Salpeter IMF’, instead of originally adopted ‘SFH = 50 Myr, α = 0, αCE = 0.5, ηEdd = 100, f = 0.5, σkick = 150 km s⁻¹ and the KROUPA01 IMF’. On journal page 1190, the second sentence after equation (5) should be ‘ηbol the bolometric correction factor . . . adopted as 0.4 for BH-XRBs and 0.2 for NS-XRBs, respectively (Belczynski et al. 2008) . . .’ instead of ‘ηbol the bolometric correction factor . . . adopted as 0.4 . . .’. Now ηbol is further increased by a factor of 1.5, i.e. adopted as 0.6 for BH-XRBs and 0.3 for NS-XRBs, respectively.

The corrected normalization affects Fig. 8. The overall shape of the XLF for each model is unaffected generally in the figure, the great change here is the different range of the N(>L) axis each curve occupies, which is shown in Fig. 1 (this figure updates Fig. 8 in the printed version of the paper). For example, the model with σkick = 150 km s⁻¹ is shifted downwards by a factor of ~2–3 compared with the original one. Note that models with σkick = 150, 130, 110 and 80 km s⁻¹ all have similar shapes, but the normalization is different, varying by several folds (~5). This adds a new parameter to the uncertainty of the normalization of the simulated XLF, besides the parameters which have already been explored in the original Fig. 6. Specifically, two parameters (i.e. f and ηEdd) only affect the normalization of the XLF. They show some degeneracy, and may affect the normalization by several folds up to even one order of magnitude in combination. From this aspect, we may see that the constraint on the natal kick is still very uncertain, and the value of σkick may be of the order of ~100–150 km s⁻¹.

REFERENCES

APPENDIX A
We used the modified equations 1 and 2 in Liu & Li (2007) to calculate the normalization. The formulae are as follows:

\[ \frac{2S_\text{b}}{S_\text{b} + 2S_\text{b}} = f, \]  \hspace{1cm} (A1)

where f is the binary fraction, adopted as 0.5 in the basic model, S_b and S_b (in unit of yr⁻¹) denote the specific star formation rates of single and binary star populations, respectively. And,

\[ S_\text{b} \int_{M_{\text{low}}}^{M_{\text{up}}} m_1 \xi(m_1) \, dm_1 + S_\text{b} \int_{M_{\text{low}}}^{M_{\text{up}}} \xi(m_1) \left( \int_{m_{\text{low}}}^{m_{\text{up}}} \frac{m_2}{m_1} \, dm_2 \right) \, dm_1 \]

\[ + S_\text{s} \int_{M_{\text{low}}}^{M_{\text{up}}} m_1 \xi(m) \, dm = 1.0, \]  \hspace{1cm} (A2)
where $\xi(m)$ is the IMF, $M_{\text{low}}$ and $M_{\text{up}}$ are the mass range for the normalization.

In the original paper, $\xi(m) = 0.143 \times m^{-2.3}$ (for $0.5 < m < +\infty$), $M_{\text{low}} = 5 M_\odot$, $M_{\text{up}} = +\infty$. Combining equations 1 and 2, we have $S_b = 0.989$.

For Salpeter IMF, $\xi(m) = 0.06 \times m^{-2.35}$ (0.1 < $m$ < 100), $M_{\text{low}} = 0.1 M_\odot$, $M_{\text{up}} = 100 M_\odot$. Then, we get $S_b = 0.837$.

Considering that the power-law slope is similar for the two IMFs in the high end (important for the high-mass X-ray binary creation), the normalization was overestimated by a factor of ~3 in the original paper.

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