European Week of Astronomy and Space Science (Athens, 4-8 July 2016)
EWASS Symposium 16: *Frontiers of massive-star evolution and core-collapse supernovae*

The impact of bars on the radial distribution of supernovae in disc galaxies

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Abstract

We present an analysis of the impact of bars on the radial distributions of the different types of supernovae (SNe) in the stellar discs of host galaxies with various morphologies. We find that in Sa–Sbc galaxies, the radial distribution of core-collapse (CC) SNe in barred hosts is inconsistent with that in unbarred ones, while the distributions of SNe Ia are not significantly different. At the same time, the radial distributions of both types of SNe in Sc–Sm galaxies are not affected by bars. We propose that the additional mechanism shaping the distributions of Type Ia and CC SNe can be explained within the framework of substantial suppression of massive star formation in the radial range swept by strong bars, particularly in early-type spirals. The radial distribution of CC SNe in unbarred Sa–Sbc galaxies is more centrally peaked and inconsistent with that in unbarred Sc–Sm hosts, while the distribution of SNe Ia in unbarred galaxies is not affected by host morphology. These results can be explained by the distinct distributions of massive stars in the discs of early- and late-type spirals.

Summary

This is a brief summary of Hakobyan et al. (2016), written for a short contribution in the EWASS-2016 Symposium 16 *"Frontiers of massive-star evolution and core-collapse supernovae"*. In the mentioned paper, using a well-defined and homogeneous sample of SNe and their host galaxies from the coverage of Sloan Digital Sky Survey (Hakobyan et al., 2012), we analysed the impact of bars on the radial distributions of the different types of SNe in the stellar discs of host galaxies with various morphologies. Our sample consists of 419 nearby (≤ 100 Mpc), low-inclination ($i \leq 60°$), and morphologically non-disturbed S0–Sm galaxies, hosting 500 SNe in total.

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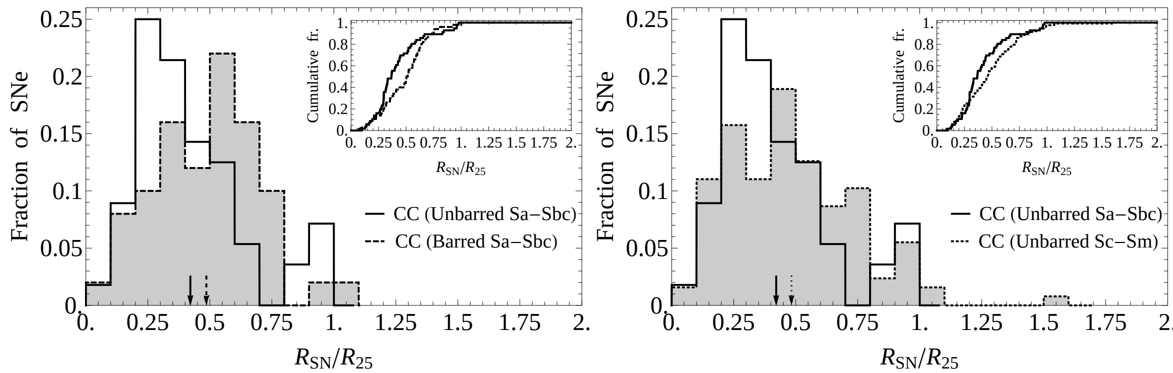

Figure 1: Left: the distributions of deprojected and normalized galactocentric radii of CC SNe in barred and unbarred Sa–Sbc hosts. Right: the distributions of CC SNe in unbarred Sa–Sbc and Sc–Sm galaxies. The insets present the cumulative distributions of SNe. The mean values of the distributions are shown by arrows.

All the results that we summarize below concerning the radial distributions of SNe in barred galaxies can be explained considering the strong impact of the bars on the distribution of massive star formation in stellar discs of galaxies, particularly in early-type spirals.

1. In Sa–Sm galaxies, all CC and the vast majority of Type Ia SNe belong to the disc, rather than the bulge component. The result suggests that the rate of SNe Ia in spiral galaxies is dominated by a relatively young/intermediate progenitor population. This observational fact makes the deprojection of galactocentric radii of both types of SNe a key point in the statistical studies of their distributions.

2. The radial distribution of CC SNe in barred Sa–Sbc galaxies is not consistent with that of unbarred Sa–Sbc hosts (left-hand panel of Fig. 1), while for Type Ia SNe the distributions are not significantly different. At the same time, the radial distributions of both Type Ia and CC SNe in Sc–Sm galaxies are not affected by bars. These results are explained by a substantial suppression of massive star formation in the radial range swept by strong bars of early-type barred galaxies (James et al., 2009; James & Percival, 2015).

3. The radial distribution of CC SNe in unbarred Sa–Sbc galaxies is more centrally peaked and inconsistent with that in unbarred Sc–Sm hosts (right-hand panel of Fig. 1). On the other hand, the radial distribution of Type Ia SNe in unbarred galaxies is not affected by host morphology. These results can be well explained by the distinct distributions of massive stars in the discs of early- and late-type spirals. In unbarred Sa–Sbc galaxies, star formation is more concentrated to the inner regions (Hα emission outside the nucleus, e.g. James et al., 2009) and should thus be responsible for the observed radial distribution of CC SNe.

4. The radial distribution of CC SNe, in contrast to Type Ia SNe, is inconsistent with the exponential surface density profile, because of the central ($R_{\rm SN}/R_{25} \leq 0.2$) deficit of

SNe. However, in the $R_{\rm SN}/R_{25} \in [0.2; \infty)$ range, the inconsistency vanishes for CC SNe in most of the subsamples of spiral galaxies. In the inner-truncated disc, only the radial distribution of CC SNe in barred early-type spirals is inconsistent with an exponential surface density profile, which appears to be caused by the impact of bars on the radial distribution of CC SNe.

5. In the inner regions of non-disturbed spiral hosts, we do not detect a relative deficiency of Type Ia SNe with respect to CC, contrary to what was found by other authors (e.g. Wang et al., 1997), who had explained this by possibly stronger dust extinction for Type Ia than for CC SNe. Instead, the radial distributions of both types of SNe are similar in all the subsamples of Sa–Sbc and Sc–Sm galaxies, which supports the idea that the relative increase of CC SNe in the inner regions of spirals found by the other authors is most probably due to the central excess of CC SNe in disturbed galaxies (e.g. Habergham et al., 2012; Hakobyan et al., 2014).

6. As was found in earlier studies (e.g. Boissier & Prantzos, 2009; Anderson & James, 2009; Hakobyan et al., 2009), the physical explanation for the more concentrated distribution of SNe Ibc with respect to SNe II in non-disturbed and unbarred spiral galaxies is that SNe Ibc arise from more metal-rich environments. The radial distributions of Types Ib and Ic SNe are sufficiently similar that the statistical tests fail to distinguish them with significance.

Acknowledgments

This work was supported by the RA MES State Committee of Science, in the frames of the research project number 15T–1C129. This work was made possible in part by a research grant from the Armenian National Science and Education Fund (ANSEF) based in New York, USA.

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