Massive Stars Near and Far
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Progenitors and companions of stripped-envelope supernovae

E. Zapartas[1], O. Fox[2], T. Fragos[3,4], M. Renzo[5], J. Andrews[6], S. S. Bavera[3,4], A. Dotter[6], M. Drout[7,8], S. van Dyk[9], D. Milisavljevic[10,11], K. Kovlakas[3], D. Misra[3], K. Rocha[5], N. Smith[12], B. Williams[13] and Z. Xing[3,4]

[1]IAASARS, National Observatory of Athens, Penteli, Greece.
email: ezapartas@gmail.com

[2]Space Telescope Science Institute, Baltimore, USA.

[3]Department of Astronomy, University of Geneva, Versoix, Switzerland.

[4]Gravitational Wave Science Center (GWSC), Universite de Geneve, Switzerland

[5]Center for Computational Astrophysics, Flatiron Institute, NY, USA.

[6]Center for Interdisciplinary Exploration and Research in Astrophysics (CIERA) and Department of Physics and Astronomy, Northwestern University, Evanston, IL, USA.

[7]David A. Dunlap Department of Astronomy and Astrophysics, University of Toronto, Canada.

[8]Observatories of the Carnegie Institution for Science, Pasadena, CA, USA.

[9]Caltech/IPAC, Pasadena, CA, USA.

[10]Department of Physics and Astronomy, Purdue University, West Lafayette, IN,USA.

[11]Integrative Data Science Initiative, West Lafayette, IN, USA.

[12]Steward Observatory, University of Arizona, Tucson, AZ, USA.

[13]University of Washington, Seattle, WA, USA

Abstract. In this poster, using the POSYDON code, we present results on binary progenitors of stripped-envelope SNe and their companions. We find that most progenitors are expected to explode, according to typical SN prescriptions (in contrast to single star progenitors). We also show the expected masses and position in the HR diagram of the companions of these SNe at the moment of explosion, allowing us to do a first statistical comparison with the compiled sample of observational detections (or upper limits) on these companions.

Keywords. stripped-envelope supernovae, massive stars, binary stars

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Stripped-envelope supernovae (SNe Ib, Ic and IIb mainly) have stellar progenitors with (almost) no hydrogen-rich envelope. In Zapartas et al. (2021) we estimate the explodability of massive, single-star MESA models (e.g., Paxton et al. 2011) of solar metallicity that reach core carbon exhaustion, simulated with POSYDON (Fragos et al. 2022)that get stripped due to their winds, according to various core-collapse SN prescriptions. Overall, we find that most Wolf-Rayet progenitors of stripped-envelope SNe are not expected to explode, with higher rates of successful Type IIb SNe. Increased mass loss rates are found in principle to work in favor of successful hydrogen-poor SNe, but they are not supported by observations (e.g., Smith 2014).

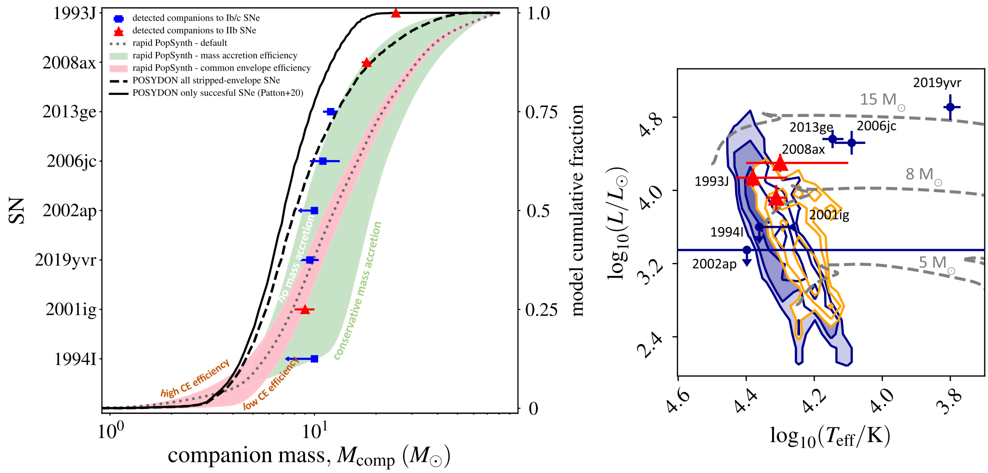

Figure 1. Left: Observed cumulative distribution of the detected mass of binary companions to stripped envelope SNe (squares for Ib/c, triangles for IIb), compared with model predictions from binary_c (dotted line and shadowed regions) and POSYDON (black solid and dashed line). Right: Hertzsprung Russel diagram of companions detections (points) compared to POSYDON predictions (blue contours for Ib/c, orange for IIb).

Stripping due to a binary companion is an alternative scenario for these SNe. In a binary population synthesis run with POSYDON (of only solar metallicity for now), we find an increased rate of successful Ib/c SNe (e.g. Laplace et al. 2021) of 81% (vs 1% for single stars) and 95% (vs 21% for single stars) according to Patton & Sukhbold (2020), which is the most pessimistic SN prescription in Zapartas et al. (2021). According to our models, all binary Ib/c SNe are in practice Ib, not Ic, having high surface helium abundance (e.g., Aguilera-Dena et al. 2022).

Observations of possible binary companions that stripped the SN progenitor provide extra information about the progenitor systems. The observed sample (e.g., Maund et al. 2004, Van Dyk et al. 2016, Fox et al. 2022) has reached a point where we can start looking at it from a population perspective. In the left panel of Fig. 1 we show the cumulative distribution of the companion mass at the moment of the stripped-envelope explosion and compare them with predictions from rapid population synthesis (Zapartas et al. 2017) and detailed binary populations with POSYDON. POSYDON's assumed mass-accretion cap due to spin-up of the accretor close to critical rotation, leads to low mass expected companions, consistent with those from rapid codes when no mass accretion is assumed. Observed distribution (including 2019yvr Ibn YHG companion and 2002ap Ic-BL's companion) shows instead a very sharp rise at around 10 $M_\odot$, with no broad tails on either side.

According to POSYDON, binary companions are expected to predominantly reside at their main sequence (MS, contours in the right panel of Fig 1), consistent also with Zapartas et al. 2017. Three detections of companions to Ib/c SNe are cooler than expected for MS stars. These could be stars evolved off-MS (which is a rare model prediction) or, in case of post-explosion detections, they can be companions that interacted with the SN ejecta (Hirai et al. 2018). Type IIb SNe companions are among the most massive observed (red triangles) and reside in the high luminosity regime of the predicted bulk of MS companions.

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