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A systematic method to identify runaways from star clusters produced from single-binary interactions: A case study of M67

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Runaway stars are thought to have been ejected from star clusters with high velocities relative to the cluster centre-of-mass motion. There are two competing mechanisms for their production: supernova-based ejections in binaries, where one companion explodes leaving no remnant and launching the other companion at the instantaneous orbital velocity, and the disintegration of triples (or higher-order multiples) producing a recoiled runaway binary (RB) and a runaway star (RS).
After discussing the theoretical expectations for both mechanisms, we search for runaway star candidates using data from the Gaia DR3 survey, with a focus on triple disintegration in the old open cluster M67. We create a systematic methodology to look for candidate RS/RB runaway pairs produced from the disintegration of bound three-body systems formed from single-binary interactions, based on momentum conservation and causality. The method is general, and can be applied to any cluster having a 5D kinematic data set. We use our criteria to search for these pairs in a 150 pc circular field of view surrounding the open cluster M67, which we use as a benchmark cluster to test the robustness of our method. Our results reveal only one RS/RB pair that is consistent with all of our selection criteria, out of an initial sample size of $\sim 10^8$ pairs (i.e., $\sim 10^4$ objects).

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