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The Four-Body Problem in Newtonian Gravity

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Each outcome of the four-body problem can be regarded as some variation of the three-body problem. For example, when two single stars are produced (the 2 + 1 + 1 outcome), each ejection event is modeled as its own three-body interaction by assuming that the ejections are well separated in time. For each outcome, we derive, using the density-of-states formalism, analytical distribution functions that describe the properties of the products of chaotic four-body interactions. We perform a set of scattering simulations in the equal-mass point-particle limit to validate these results, and identify regions of parameter space that our model is not suited for. The agreement is strong, and highlights the importance of the initial semi-major axes. Binary-binary scatterings act to systematically destroy binaries. Instead they produce a binary and two ejected stars when the initial binary semi-major axes are similar, or a stable triple when the initial semi-major axes are very different. The 2 + 2 outcome produces the widest binaries, and the 2 + 1 + 1 outcome produces the most compact binaries. Hence, four-body interactions in clusters should act to systematically destroy binaries , independent of the initial orbital separation distribution.

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