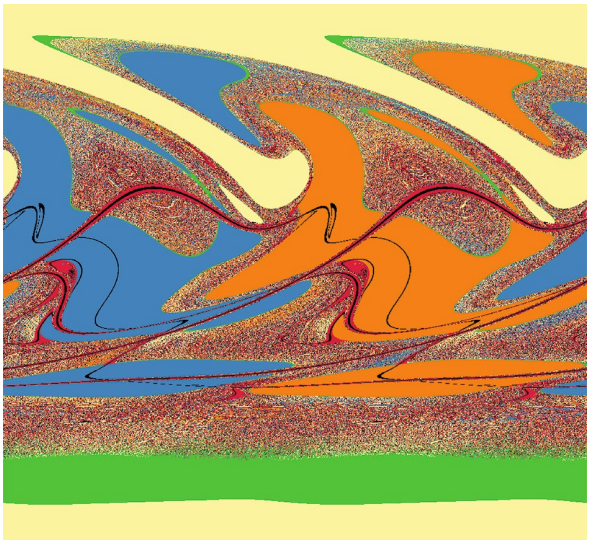
Nature Reviews Physics | https://doi.org/10.1038/s42254-019-0141-4 | Published online 19 December 2019

MATHEMATICAL PHYSICS

Three bodies, no problem

The three-body problem is often given as an example of a mathematical problem that 'can't be solved'. In other words, there is no general analytical solution, and the dynamics of the system are chaotic (pictured). The three-body problem is not only a mathematical curiosity, it also finds application in astrophysics. For example, a third body scattering off an orbiting pair can lead to that pair having highly eccentric orbits; their merger would then yield unique gravitational wave signals. Now, writing in *Nature*, Nicholas Stone and Nathan Leigh report a statistical solution — a formula that gives the probability distribution of final states of the system given its initial state.



Credit: Image adapted with permission from Samsing, J. & Ilan, T. Mon. Not. R. Astron. Soc. 476, 1548–1560 (2018), Oxford University Press

Stone and Leigh's approach works by taking advantage of the chaos that hinders a general solution. Chaotic systems tend to mix themselves up, so it is often safe to assume that apart from the constants of motion, such as the total energy, the system forgets its initial conditions after some time, and explores all of its phase space. Stone and Leigh used this assumption to construct the outcome distributions for a system with conserved energy and total angular momentum. Although similar approaches have been tried before, the new work involves fewer assumptions and results in qualitatively different distributions of outcomes. The distributions agree well with those obtained in numerical simulations of three-body systems that go through two or more 'scrambles', that is, periods of time in which the three bodies move around without any two forming a pair that orbit each other. Such scrambles appear to be a mechanism that helps the system to explore its phase space.

Zoe Budrikis

ORIGINAL ARTICLE Stone, N. C. & Leigh, N. W. C. A statistical solution to the chaotic, non-hierarchical three-body problem. *Nature* https://doi.org/10.1038/s41586-019-1833-8 (2019).
RELATED ARTICLE Samsing, J. & Ilan, T. Topology of black hole binary–single interactions. *Mon. Not. R. Astron. Soc.* **476**, 1548–1560 (2018).