Stochasticity on Astronomical Scales: A Half-life Formalism for Predicting the Disruption of Small-N Body Systems

Ibragimov, Timur (School: Staten Island Technical High School)

In this enterprise, a formalism for describing the outcome of binary-binary chaotic interactions has been developed from computer simulations and mathematical models. In 1899, Henri Poincaré proved that there is no general solution of the N-body problem. Computer orbital integrations are, to date, the most astrophysicists can do to approximate the outcome of such gravitationally-chaotic systems, which are often computationally expensive and simplistic. However, in nature, other distinct systems have similar chaotic behavior, such as decaying radioisotopes and the geochronological methods used to analyze them. The objective of this study is to apply and evaluate the validity of such well-defined methods, such as half-life decay, to these astrophysical systems. Raw data extracted from 600,414 scattering trials of binary-binary interactions was utilized. Distributions of all disruption times were plotted and analyzed with mathematical models. Half-lives of each system were then extracted, and branching ratios calculated. It was found that the half-life models used here strongly agreed with the observed behavior of these chaotic systems from simulations, indicating initial success of this model. Moreover, the specific conditions by which these models successfully work indicates the possible statistical mechanism that drives such systems. Lastly, it was found that half-lives largely depend on the specific type of outcome from disruption. This half-life framework can be adapted into timely astrophysical phenomena, such as for predicting gravitational-wave detections. It can also be used to determine multiplicities of populations of stars, black holes, and other point sources, in a well-known cosmic setting.

Awards Won:

Third Award of $1,000

National Aeronautics and Space Administration: First Award of $2500