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FORMATION ANALYSIS OF THE DIDYMOS-DIMORPHOS BINARY ASTEROID SYSTEM

Abstract

Through the analysis of the effects of tidal disruption, collisional events, and rotational fission on asteroids, unique remnant characteristics can be found in binary asteroid systems related to their formation mechanisms. Binary asteroid systems are often the result of rubble-pile asteroids that have split but remain orbitally bound to each other. In this work, a granular model of a progenitor asteroid is created using the soft-sphere discrete element method (SSDEM) for particle interactions. A baseline model will be established, that is slightly larger than the combined mass of Didymos and Dimorphos to account for mass loss during the formation process. By creating a baseline granular model, the posited formation mechanisms and their results can be directly compared and analyzed for each mechanism's unique remnant characteristics as well as progenitor characteristics. Probability distributions have been created for the progenitor's characteristic parameters as well as all relevant formation mechanism parameters. A Monte Carlo sensitivity analysis is performed using the probability distributions and the granular model for each formation mechanism in order to determine the range of input parameters that result in binary formation. An analysis is performed to generate a series of binary systems using the narrowed range of parameters to assess outcomes (e.g., system dynamics, geometries, mass distributions) that result in a binary system akin to Didymos and Dimorphos. From the analysis, probable formation mechanisms associated with a binary system are proposed, given the progenitor asteroid model. Investigating the formation mechanisms of observable binary asteroid systems can help further knowledge pertaining to the origins of multibody systems in the solar system. In particular, determining a formation mechanism for the Didymos and Dimorphos pair will enable further studies on data collected during the Double Asteroid Redirection Test (DART) mission; notably, research can be performed that benefits from information on the asteroids prior to the mission—as well as before the formation event. This may include research on possible alternative orbital outcomes of kinetic impacts similar to the DART mission. This data could also be relevant to future asteroid missions to binary asteroids. This includes informing the instrumentation and orbital paths of spacecraft to best collect data related to remnant characteristics of formation mechanisms, as well as the desired locations to obtain samples that may provide insight into the origination of the binary asteroid system.