Abstract

In the late stages of terrestrial planet formation, pairwise collisions between planetary-size bodies act as the fundamental agent of planet growth. These collisions can lead to either growth or disruption of the bodies involved and are largely responsible for shaping the final characteristics of the planets. Despite their critical role in planet formation, an accurate treatment of collisions has yet to be realized. This problem is of particular importance in the context of N-body simulations, wherein tens of thousands of collisions can occur. While analytic and semi-analytic methods have been proposed, they remain limited to a narrow set of post-impact properties and have only achieved relatively low accuracies. A number of problems need to be overcome in order to accurately treat collisions within N-body simulations. However, the rise of machine learning and access to increased computing power have enabled novel data-driven approaches. In this work, we show that data-driven emulation techniques are capable of predicting the outcome of collisions with high accuracy and are generalizable to any quantifiable post-impact property. In addition, we introduce novel methods for handling the debris field and identifying circumplanetary disks. For this work, we simulated a new set of 10,700 SPH simulations of pairwise collisions between 21,400 rotating, differentiated bodies at all possible mutual orientations.