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# *Applying Machine Learning to Giant-Impact Studies of Planet Formation*

Alexandre Emsenhuber (University of Arizona) and five colleagues from University of Arizona and Arizona State University study the formation of planets and planetary systems through computer modeling of orbital dynamics and the physical processes involved in collisions. They use Smooth Particle Hydrodynamics (SPH) code to model giant impacts during the late-formation stages of planets, such as the Moon, Mercury, and Mars.

(from Asphaug *et al.*, 2006, *Nature*, v. 439, p. 155-160.)

The team is particularly interested in combining these model datasets with machine learning. With machine learning, they have streamlined a set of 800 SPH simulations of giant impacts to quickly analyze the data and predict collision outcomes because of the automatic learning of giant-impact physics and improving predictive capabilities that machine learning provides. With this training set of hundreds of SPH simulations, Emsenhuber and colleagues create and use a surrogate model for giant impacts that allows them to predict, as realistically as possible, such details as the loss of mass and trajectories of impacting bodies and targets, and the evolution of the left-over debris of hit-and-run collisions.

Using a surrogate SPH model reduces the computational time compared to running full SPH simulations, and the research shows no downgrading of accuracy of the results. Such results–predicted collision outcomes– are then used in *N*-body dynamical simulations of planetary formation. The team plans future work to extend the training dataset to include pre-impact rotation conditions, variable thermal conditions, and bodies less than a few thousands of kilometers in diameter to account for friction. This creative combination of giant-impact studies and machine learning builds on the long-standing aspiration to better understand the long chain of events, collisions, mergers, and accretions that formed our planets.

The open-source code developed in this work is available at ***github.com/aemsenhuber/collresolve***.

See Reference:

· Emsenhuber, A., Cambioni, S., Asphaug, E., Gabriel, T. S. J., Schwartz, S. R., and Furfaro, R. (2020) Realistic On-the-fly Outcomes of Planetary Collisions II: Bringing Machine Learning to *N*-body Simulations, *The Astrophysical Journal,* v. 891, 6, doi: 10.3847/1538-4357/ab6de5. [***article***]

See also:

· Cambioni, S., Asphaug, E., Emsenhuber, A., Gabriel, T. S. J., Furfaro, R. and Schwartz, S. R. (2019) Realistic On-the-fly Outcomes of Planetary Collisions: Machine Learning Applied to Simulations of Giant Impacts, *The Astrophysical Journal,* v. 875, 40, doi: 10.3847/1538-4357/ab0e8a. [***article***]

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Written by Linda Martel, Hawai'i Institute of Geophysics and Planetology, for ***PSRD***.

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