

Giant impact could have formed the Moon more rapidly, scientists reveal in new simulations

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Credit: Dr Jacob Kegerreis

Scientists from Durham University's Institute for Computational Cosmology used the most detailed supercomputer simulations yet to reveal an alternative explanation for the Moon's origin, with a giant impact immediately placing a Moon-like body into orbit around Earth.

The researchers simulated hundreds of different impacts, varying the angle and speed of the collision as well as the masses and spins of the two colliding bodies in their search for scenarios that could explain the present-day Earth-Moon system. These calculations were performed using the SWIFT open-source [simulation](#) code, run on the DiRAC Memory Intensive service ("COSMA"), hosted by Durham University on behalf of the DiRAC High-Performance Computing facility.

The extra computational power revealed that lower-resolution simulations can miss out on important aspects of large-scale collisions, allowing researchers to discover features that weren't accessible for previous studies. Only the high-resolution simulations produced the Moon-like satellite, and the extra detail showed how its outer layers were richer in material originating from the Earth.

If much of the Moon formed immediately following the giant impact, then this could also mean that less became molten during formation than in the standard theories where the Moon grew within a debris disk around Earth. Depending upon details of the subsequent solidification, these theories should predict different internal structures for the Moon.



Credit: Dr Jacob Kegerreis

Co-author of the study, Vincent Eke, said: "This formation route could help explain the similarity in [isotopic composition](#) between the [lunar rocks](#) returned by the Apollo astronauts and Earth's mantle. There may also be observable consequences for the thickness of the lunar crust,

which would allow us to pin down further the type of collision that took place."

Furthermore, they found that even when a satellite passes so close to the Earth that it might be expected to be torn apart by the "[tidal forces](#)" from Earth's gravity, the satellite actually can not only survive but also be pushed onto a wider orbit, safe from future destruction.

Lead researcher of the study, Jacob Kegerreis, said: "This opens up a whole new range of possible starting places for the Moon's evolution. We went into this project not knowing exactly what the outcomes of these very high-resolution simulations would be. So, on top of the big eye-opener that standard resolutions can give you wrong answers, it was extra exciting that the new results could include a tantalizingly Moon-like satellite in orbit."

The Moon is thought to have formed following a collision 4.5 billion years ago between the young Earth and a Mars-sized object, called Theia. Most theories create the Moon by gradual accumulation of the debris from this impact. However, this has been challenged by measurements of lunar rocks showing their composition is like that of Earth's mantle, while the impact produces debris that comes mostly from Theia.

This immediate-satellite scenario opens up new possibilities for the initial lunar orbit as well as the predicted composition and internal structure of the Moon. The many upcoming lunar missions should reveal new clues about what kind of giant impact led to the Moon, which in turn will tell us about the history of Earth itself.

The research team included scientists at NASA Ames Research Center and the University of Glasgow, UK, and their simulation findings have been published in the *Astrophysical Journal Letters*.

More information: J. A. Kegerreis et al, Immediate origin of the Moon as a post-impact satellite, *Astrophysical Journal Letters* (2022). www.hou.usra.edu/meetings/lpsc2022/pdf/1724.pdf , iopscience.iop.org/article/10.1088/1361-8213/ac8d96

Provided by Durham University

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