# Researchers propose new type of planetary object

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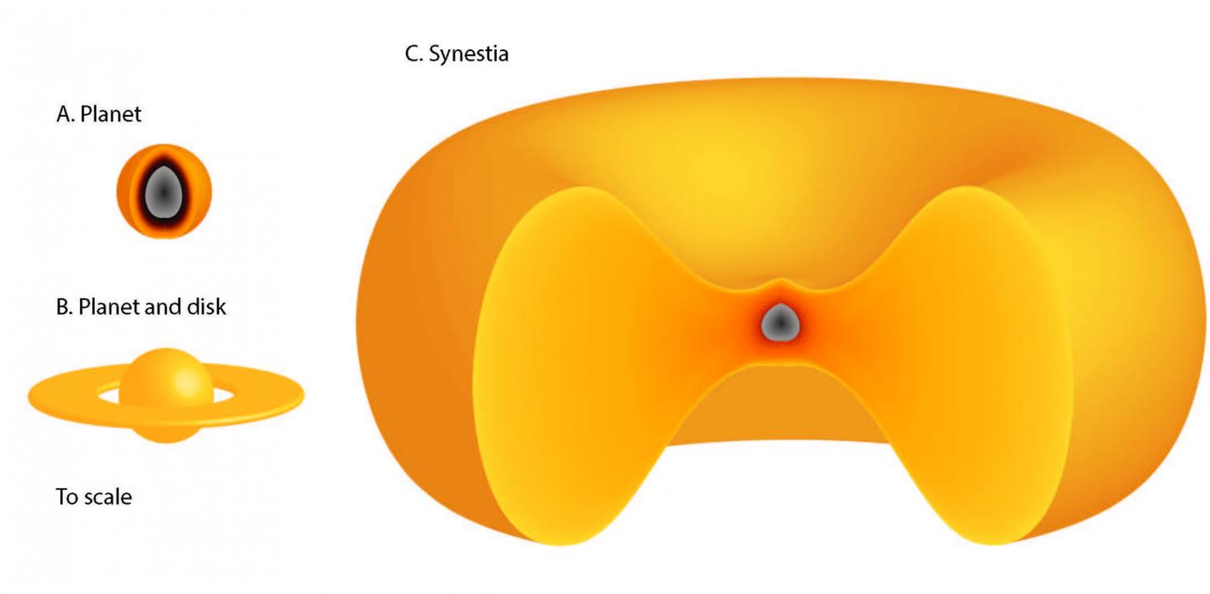


The structure of a planet, a planet with a disk and a synestia, all of the same mass. Credit: Simon Lock and Sarah Stewart.

Scientists suggest in a new study the existence of a planetary object called a "synestia," a huge, spinning, donut-shaped mass of hot, vaporized rock, formed as planet-sized objects smash into each other.

At one point early in its history, Earth was likely a synestia, said Sarah Stewart, a planetary scientist at the University of California Davis and co-author of the new study in the *Journal of Geophysical Research*: *Planets*, a journal of the American Geophysical Union.

Stewart and Simon Lock, a graduate student at Harvard University in Cambridge, Massachusetts and lead author of the new study, explore how planets can form from a series of giant impacts. Current theories of planet formation hold that rocky planets such as Earth, Mars and Venus formed early in the solar system when smaller objects smashed into each other.

These collisions were so violent that the resulting bodies melted and partially vaporized, eventually cooling and solidifying to the nearly spherical planets we know today.

Lock and Stewart are particularly interested in collisions between spinning objects. A rotating object has angular momentum, which must be conserved in a collision. Think of a skater spinning on ice: if she extends her arms, she slows her rate of spin. To spin faster, she holds her arms close by her side, but her angular momentum stays constant.

Now consider two skaters turning on ice: if they catch hold of each other, the angular momentum of each skater adds together so that their total angular momentum stays the same.

In the new study, Lock and Stewart modeled what happens when the "ice skaters" are Earth-sized rocky planets colliding with other large objects with both high energy and high angular momentum.

"We looked at the statistics of giant impacts, and we found that they can form a completely new structure," Stewart said.

Lock and Stewart found that over a range of high temperatures and high angular momenta, planet-sized bodies could form a new, much larger structure, an indented disk rather like a red blood cell or a donut with the center filled in. The object is mostly vaporized rock, with no solid or liquid surface.

They have dubbed the new object a "synestia," from "syn-," "together" and "Estia," Greek goddess of architecture and structures.

The key to synestia formation is that some of the structure's material goes into orbit. In a spinning, solid sphere, every point from the core to the surface is rotating at the same rate. But in a giant impact, the material of the planet can become molten or gaseous and expands in volume. If it gets big enough and is moving fast enough, parts of the object pass the velocity needed to keep a satellite in orbit, and that's when it forms a huge, disc-shaped synestia, according to the new study.

Previous theories had suggested that giant impacts might cause planets to form a disk of solid or molten material surrounding the planet. But for the same mass of planet, a synestia would be much larger than a solid planet with a disk.

Most planets likely experience collisions that could form a synestia at some point during their formation, Stewart said. For an object like Earth, the synestia would not last very long – perhaps a hundred years – before it lost enough heat to condense back into a solid object. But synestia formed from larger or hotter objects such as gas giant planets or stars could potentially last much longer, she said.

The synestia structure also suggests new ways to think about lunar formation. The moon is remarkably like Earth in composition, and most current theories about how the moon formed involve a giant impact that threw material into orbit. But such an impact could have instead formed a synestia from which the Earth and Moon both condensed, Stewart said.

No one has yet observed a synestia directly, but they might be found in other solar systems once astronomers start looking for them alongside rocky planets and gas giants, she said.

**More information:** The structure of terrestrial bodies: Impact heating, corotation limits, and synestias, *Journal of Geophysical Research*, DOI: 10.1002/2016JE005239 , onlinelibrary.wiley.com/doi/10 … 016JE005239/abstract

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