NATURE | NEWS

Fleeting phase of planet formation discovered

These celestial bodies coalesce into objects shaped like giant red blood cells.

Ramin Skibba

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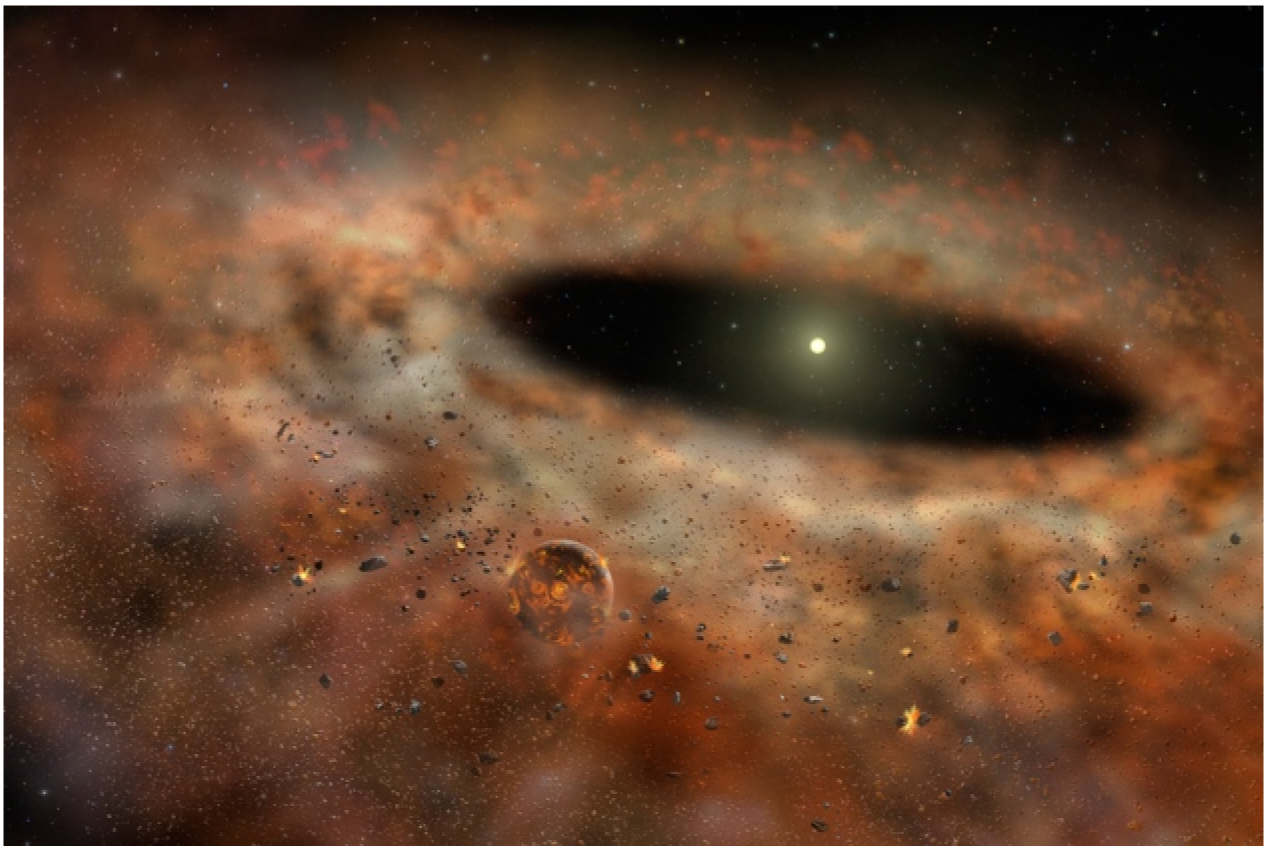


Gemini Observatory/AURA/Lynette Cook/SPL

The cloud of dust and debris around a star can give rise to a new type of celestial object during planet formation.

Rocky planets, including Earth, endure violent beginnings. Giant impacts vaporize enormous chunks of protoplanets, surrounding them in a flattened halo of debris. Scientists believe that these disks eventually condense to form planets. Now, improved computer simulations of planet formation suggest that many of these embryonic objects pass through a phase late in their adolescence in which they assume the shape of enormous red blood cells called synestia.

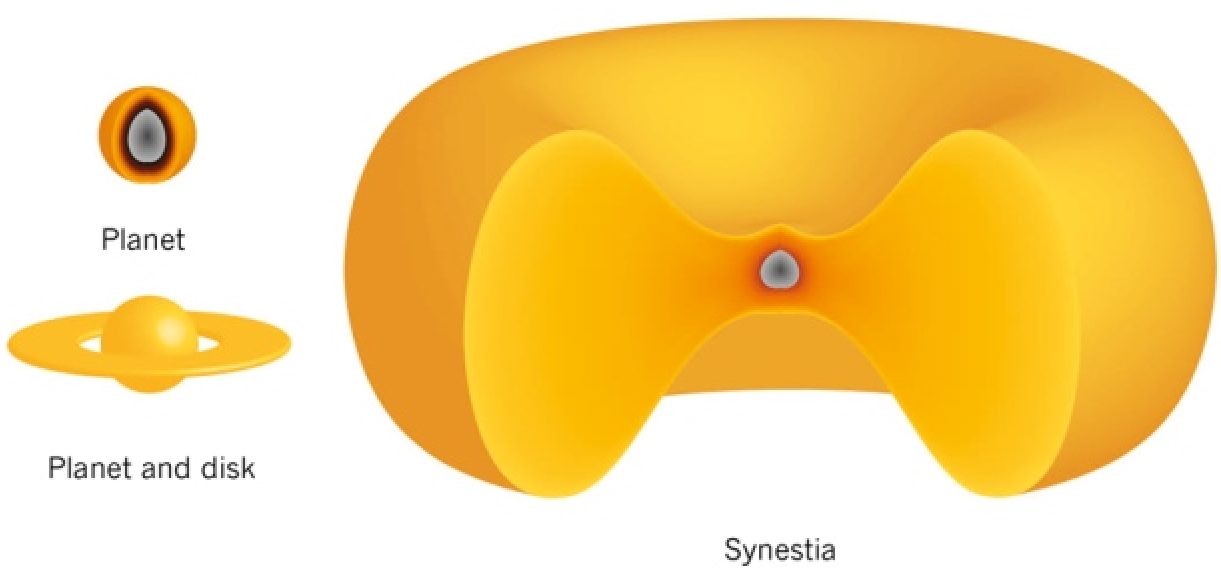
Researchers led by planetary scientist Sarah Stewart at the University of California, Davis, published their description of these huge, spinning clouds of vaporized rock on 22 May in the *Journal of Geophysical Research: Planets*[1]. The finding could help scientists to improve their understanding of planet formation, and lead to better explanations of how Earth's Moon formed.

"We discovered that there's a different class of objects where the system is rotating so quickly, and it's so hot, that there's no actual boundary between what we used to call the planet and the disk," Stewart says.

Going for a spin

In her quest to build a better model of how planets form, Stewart and her co-author Simon Lock, a planetary scientist at Harvard University in Cambridge, Massachusetts, incorporated the effects of repeated impacts with other large objects, including other protoplanets, which usually occur in the later stages of planet assembly. In this phase, a planet grows chaotically, because each collision releases incredible amounts of energy.

If a growing planet experiences a glancing blow from a giant object, the collision can throw up a cloud of pulverized material and set both the planet and the cloud spinning. The researchers' model showed that the cloud eventually becomes a single, coherent structure shaped like a red blood cell. They estimate that these structures only last for a short period: hundreds or thousands of years.



Adapted from Simon Lock and Sarah Stewart

A scale comparison of a synestia, a planet and a planet with a disk of equal mass.

“It’s a more detailed treatment that modifies the previous picture of how planets form,” says Joshua Eisner, an astronomer at the University of Arizona in Tucson, who wasn’t involved in the study. “People have seen these kinds of structures in other contexts though, like for rapidly rotating stars or even Jupiter formation models.” But rocky planet formation is much more complex, and previous models didn’t include enough information to reveal fleeting structures such as synestia.

Moonstruck

A synestia probably wouldn't form for every planet, says Donald Korycansky, a planetary scientist at the University of California, Santa Cruz, who wasn’t involved in the study. But he wouldn't be surprised if they turned out to be fairly common.

In fact, a single planet could pass through the synestia phase multiple times if it is subjected to several giant impacts. In Stewart’s simulations, more than half of the Earth-sized rocky planets withstand one giant impact as they form, and some can experience two or more such events.

Once the impacts die down and a synestia begins to cool, it shrinks and particles start to settle. The rock and debris in the outer part of the structure condense and fall back on to the embryonic planet at the centre. Any leftover material that’s far enough away from the growing planet could come together to form moons within a few thousand years. This is how Stewart and her colleagues think Earth’s Moon formed.

Current theories for the Moon’s formation posit that a Mars-sized object called Theia crashed into Earth about 4.5 billion years ago. The ejected debris from Earth and Theia eventually coalesced into the Moon. However, this ‘giant impact hypothesis’ doesn’t explain the striking chemical similarities between Earth and the Moon. But a synestia could explain those similarities, Stewart says.

She and her colleagues are currently working on modelling how Earth and its debris might have gone through a synestia phase generated by an impact with Theia.

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References

1. Lock, S. J. & Stewart, S. T. *J. Geophys. Res. Planets* http://dx.doi.org/10.1002/2016JE005239 (2017).