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Super-dense celestial bodies could be a new kind of planet

Space telescope's discoveries may be the remains of wandering ice giants.

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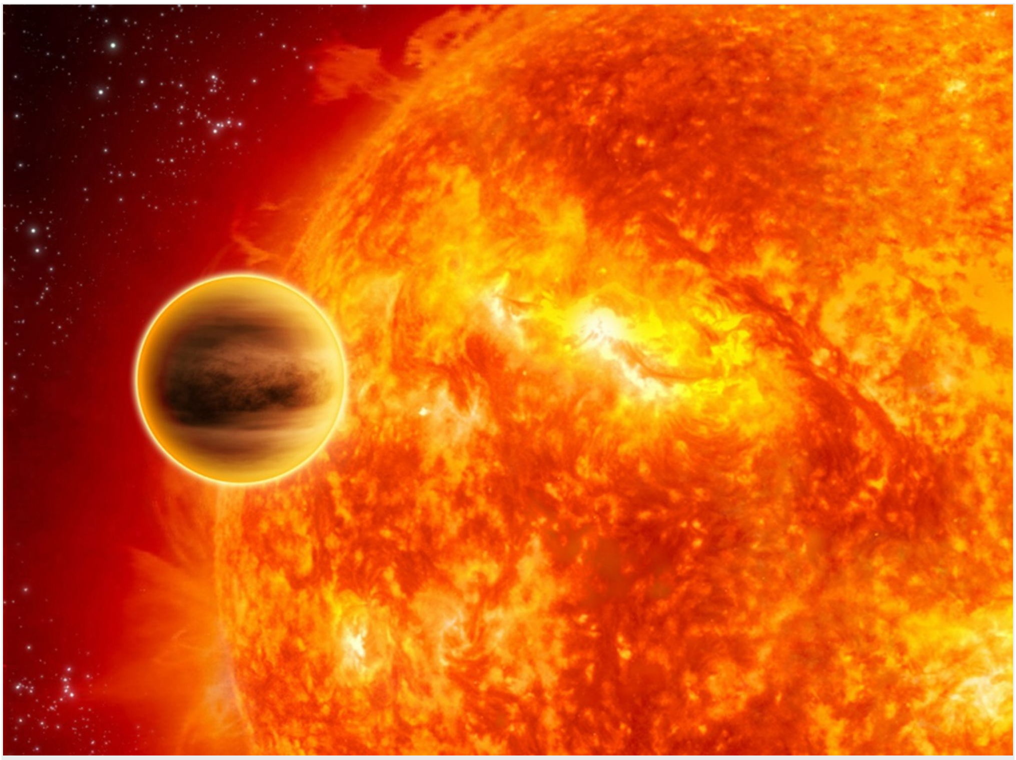

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Compressed planets may be the remnants of ice giants stripped of their outer layers by a close encounter with their suns.

Mysterious dense bodies outside the Solar System could be the remnants of ice giants similar to Neptune that wandered too close to their suns, according to results presented this week at a meeting on exoplanets at the Royal Society in London.

Among the most puzzling finds of NASA's Kepler space mission to find exoplanets, which launched in 2009, are bodies too heavy for their size. In some of the rare cases in which astronomers can estimate both the mass and the size of distant planets discovered by the probe, the objects have radiuses similar to that of Earth but are denser than pure iron.

No conventional theories about planet formation can account for such densities in planets of this size. “There is no way to explain that in the Solar System,” says Olivier Grasset, a geophysicist at the University of Nantes in France.

Fossil worlds

Grasset and his collaborators now say that the strange bodies could be the “fossil cores” of planets that were once much larger, an idea that was first proposed by researchers in 2011[1]. These planets would have been ice giants that formed in the outer parts of a star system and then migrated inwards — as their orbits were affected by interactions with surrounding gas and dust — perhaps getting as close to their suns as Mercury is to ours.

The hotter temperatures closer to the stars, Grasset explains, would evaporate the outer layers of the planets, which are made mainly of volatile components such as hydrogen, helium and water. The leftover cores would consist of rock and metal, just like the bulk of Earth, and could weigh up to several times as much as our planet, making them what scientists call super-Earths.

But these cores formed under the weight of their planets' outer layers, under pressures of around 500 gigapascals — 5 million times atmospheric pressure on Earth — and typical temperatures of about 6,000 kelvin. As a result, the materials in these cores should be more compacted, and denser, than Earth.

Quick change

Together with his colleagues Antoine Mocquet, a planetary scientist also at Nantes, and Christophe Sotin, a planetary geologist at NASA's Jet Propulsion Laboratory in Pasadena, California, Grasset created a computer simulation to test the idea.

The team found that if the outer layers of an ice giant are removed over billions of years, the materials would 'relax', expanding back to more ordinary densities. But if the stripping occurred over a geologically short time, the sudden cooling would keep the core locked into its dense state essentially forever. "If the process is short, you end up with a very compressed super-Earth," says Grasset.

Lars Stixrude, a geologist at University College London, calls the idea "fascinating" — although he warns that science's understanding of the behaviour of materials under the extreme temperatures and pressures of an ice-giant core is still incomplete. Grasset agrees that there are large uncertainties in his team's calculations, especially in the rate of relaxation of the naked cores. But, he adds, he and his colleagues made conservative assumptions.

William Borucki, a space scientist at NASA's Ames Research Center in Moffett Field, California, and leader of the Kepler mission, says that the idea is plausible, but that there could be other ways for the outer layers of an ice giant to be ripped away. The process could be the result of a cataclysmic collision with another planet-sized object, for example. Or perhaps the high-density cores could suggest that planets form through exotic processes similar to those of star formation. Whatever the implications, he says, it is exciting that Kepler's findings are upending old assumptions. "This is why we do science."

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References

1. Charpinet, S. *et al*. *Nature* **480**, 496–499 (2011).