When do gas giants reach the point of no return?

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Planetary scientists at UCL have identified the point at which a star causes the atmosphere of an orbiting gas giant to become critically unstable, as reported in this week's *Nature*. Depending upon their proximity to a host star, giant Jupiter-like planets have atmospheres which are either stable and thin, or unstable and rapidly expanding. This new research enables us to work out whether planets in other systems are stable or unstable by using a three dimensional model to characterise their upper atmospheres.

Tommi Koskinen of UCL's Physics & Astronomy Department is lead author of the paper and says: "We know that Jupiter has a thin, stable atmosphere and orbits the Sun at five Astronomical Units (AU) - or five times the distance between the Sun and the Earth. In contrast, we also know that closely orbiting exoplanets like HD209458b - which orbits about 100 times closer to its sun than Jupiter does - has a very expanded atmosphere which is boiling off into space. Our team wanted to find out at what point this change takes place, and how it happens.

"Our paper shows that if you brought Jupiter inside the Earth's orbit, to 0.16AU, it would remain Jupiter-like, with a stable atmosphere. But if you brought it just a little bit closer to the Sun, to 0.14AU, its atmosphere would suddenly start to expand, become unstable and escape. This dramatic change takes place because the cooling mechanism that we identified breaks down, leading to the atmosphere around the planet heating up uncontrollably."

Professor Alan Aylward, co-author of the paper, explains some of the factors which the team incorporated in order to make the breakthrough: “For the first time we’ve used 3D-modelling to help us understand the whole heating process which takes place as you move a gas giant closer to its sun. The model incorporates the cooling effect of winds blowing around the planet - not just those blowing off the surface and escaping.

“Crucially, the model also makes proper allowances for the effects of H3+ in the atmosphere of a planet. This is an electrically-charged form of hydrogen which strongly radiates sunlight back into space and which is created in increasing quantities as you heat a planet by bringing it closer to its star.

“We found that 0.15AU is the significant point of no return. If you take a planet even slightly beyond this, molecular hydrogen becomes unstable and no more H3+ is produced. The self-regulating, ‘thermostatic’ effect then disintegrates and the atmosphere begins to heat up uncontrollably.”

Professor Steve Miller, the final contributing author to the paper, puts the discovery into context: “This gives us an insight to the evolution of giant planets, which typically form as an ice core out in the cold depths of space before migrating in towards their host star over a period of several million years. Now we know that at some point they all probably cross this point of no return and undergo a catastrophic breakdown.

“Just twelve years ago astronomers were searching for evidence of the first extrasolar planet. It’s amazing to think that since then we’ve not only found more than 250 of them, but we’re also in a much better position to understand where they came from and what happens to them during their lifetime.”

Source: University College London

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