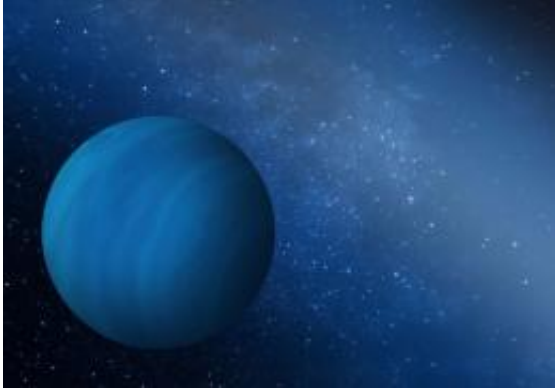


Giant planet ejected from the solar system

10 November 2011



Artist's impression of a planet ejected from the early solar system. Image courtesy of Southwest Research Institute

(PhysOrg.com) -- Just as an expert chess player sacrifices a piece to protect the queen, the solar system may have given up a giant planet and spared the Earth, according to an article recently published in *The Astrophysical Journal Letters*.

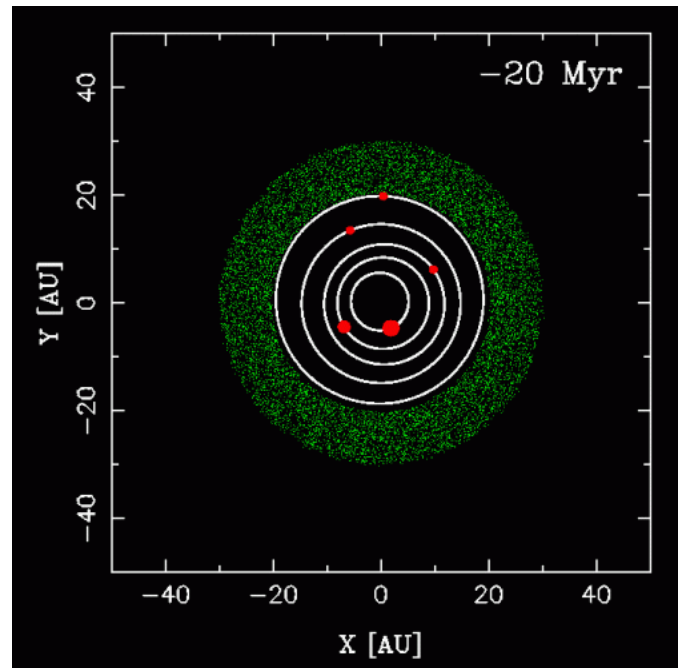
"We have all sorts of clues about the early evolution of the solar system," says author Dr. David Nesvorny of the Southwest Research Institute. "They come from the analysis of the trans-Neptunian population of small bodies known as the Kuiper Belt, and from the lunar cratering record."

These clues suggest that the orbits of giant planets were affected by a dynamical instability when the solar system was only about 600 million years old. As a result, the giant planets and smaller bodies scattered away from each other.

Some small bodies moved into the [Kuiper Belt](#) and others traveled inward, producing impacts on the [terrestrial planets](#) and the Moon. The giant planets moved as well. Jupiter, for example, scattered most small bodies outward and moved inward.

This scenario presents a problem, however. Slow changes in Jupiter's orbit, such as the ones

expected from interaction with small bodies, would have conveyed too much momentum to the orbits of the terrestrial planets. Stirring up or disrupting the [inner solar system](#) and possibly causing the Earth to collide with Mars or Venus.



This animation (click "Enlarge") shows the evolution of the planetary system from 20 million years before the instability to 30 million years after the instability (the actual simulation covered a much longer time span). Five initial planets are shown by red circles, small bodies are in green. The fifth planet is ejected at the instability, as can be seen in frame $t=0$, causing a general disorder in the region. The system of the remaining four planets stabilizes after a while, and looks like the outer solar system in the end, with giant planets at 5, 10, 20 and 30 astronomical units (AU). This is just one of more than 6,000 simulations performed to study the likelihood of planet ejection. Animation courtesy of Southwest Research Institute

"Colleagues suggested a clever way around this problem," says Nesvorny. "They proposed that Jupiter's orbit quickly changed when Jupiter

scattered off of Uranus or Neptune during the dynamical instability in the [outer solar system](#)." The "jumping-Jupiter" theory, as it is known, is less harmful to the inner solar system, because the orbital coupling between the terrestrial planets and Jupiter is weak if Jupiter jumps.

Nesvorny conducted thousands of computer simulations of the early solar system to test the jumping-Jupiter theory. He found that, as hoped for, Jupiter did in fact jump by scattering from Uranus or Neptune. When it jumped, however, Uranus or Neptune was knocked out of the solar system. "Something was clearly wrong," he says.

Motivated by these results, Nesvorny wondered whether the [early solar system](#) could have had five giant planets instead of four. By running the simulations with an additional giant planet with mass similar to that of Uranus or Neptune, things suddenly fell in place. One planet was ejected from the solar system by Jupiter, leaving four giant planets behind, and Jupiter jumped, leaving the terrestrial planets undisturbed.

"The possibility that the solar system had more than four [giant planets](#) initially, and ejected some, appears to be conceivable in view of the recent discovery of a large number of free-floating planets in interstellar space, indicating the planet ejection process could be a common occurrence," says Nesvorny.

More information: The paper, "Young Solar System's Fifth Giant Planet?" by Dr. David Nesvorny was published online by *The Astrophysical Journal Letters*.

Provided by Southwest Research Institute
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