Astrophysicists find wide binary stars wreak havoc in planetary systems

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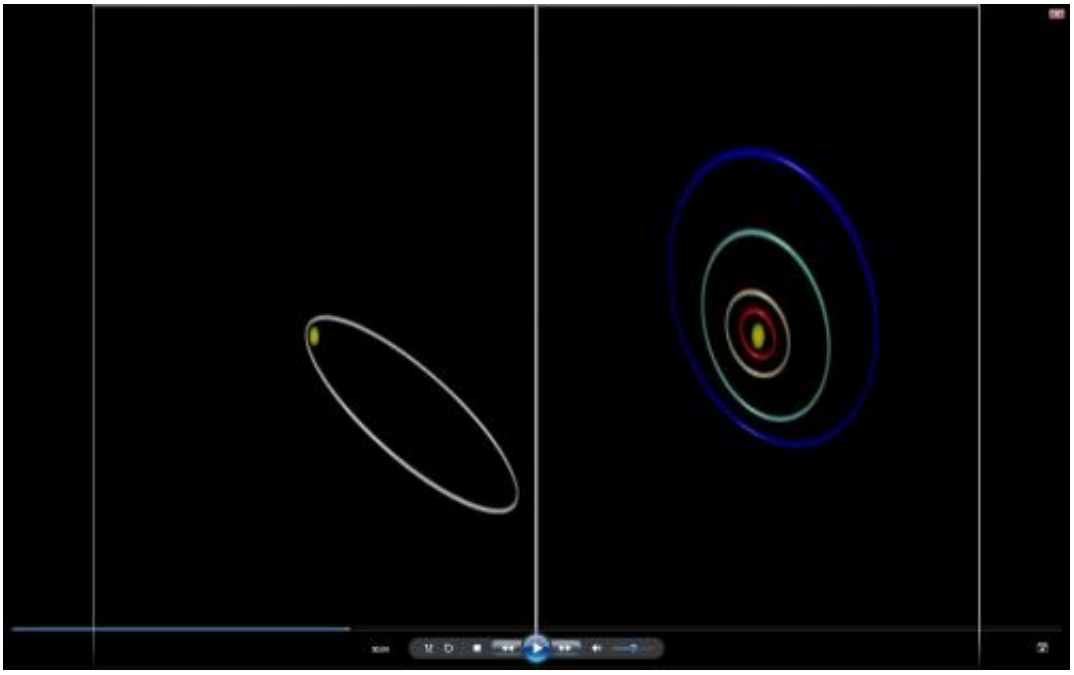

An international team of astrophysicists has shown that planetary systems with very distant binary stars are particularly susceptible to violent disruptions, more so than if they had stellar companions with tighter orbits around them.

Unlike the Sun, many stars are members of binary star systems – where two stars orbit one another – and these stars' planetary systems can be

altered by the gravity of their companion stars. The orbits of very distant or wide stellar companions often become very eccentric – ie. less circular – over time, driving the once-distant star into a plunging orbit that passes very close to the planets once per orbital period. The gravity of this close-passing companion can then wreak havoc on planetary systems, triggering planetary scatterings and even ejections.

"The stellar orbits of wide binaries are very sensitive to disturbances from other passing stars as well as the tidal field of the Milky Way," said Nathan Kaib, lead author of a study published today in *Nature* describing the findings. "This causes their stellar orbits to constantly change their eccentricity – their degree of circularity. If a wide binary lasts long enough, it will eventually find itself with a very high orbital eccentricity at some point in its life."

When a wide binary orbit becomes very eccentric, the two stars will pass very close together once per orbit on one side of the orbital ellipse, while being very far apart on the other side of the ellipse. This can have dire consequences for planets in these systems since the gravity of a close-passing star can radically change planetary orbits around the other star, causing planets to scatter off of one another and sometimes get ejected to interstellar space.

Kaib, a postdoctoral fellow in the Center for Interdisciplinary Exploration and Research in Astrophysics (CIERA) and the Department of Physics and Astronomy at Northwestern University and a National Fellow in the Canadian Institute for Theoretical Astrophysics at the University of Toronto, conducted computer simulations of the process with Queen's University physics professor Martin Duncan and Sean N. Raymond, a researcher at the University of Bordeaux and the Centre national de la recherche scientifique in France. They added a a hypothetical wide binary companion to the Earth's solar system which eventually triggered at least one of four giant planets (Jupiter, Saturn,

Uranus and Neptune) to be ejected in almost half of the simulations.

"This process takes hundreds of millions of years if not billions of years to occur in these binaries. Consequently, planets in these systems initially form and evolve as if they orbited an isolated star," said Kaib, who will present the findings this week at the 221st meeting of the American Astronomical Society in Long Beach, California. "It is only much later that they begin to feel the effects of their companion star, which often times leads to disruption of the planetary system."

"We also found that there is substantial evidence that this process occurs regularly in known extrasolar planetary systems," said Duncan. "Planets are believed to form on circular orbits, and they are only thought to attain highly eccentric orbits through powerful and/or violent perturbations. When we looked at the orbital eccentricities of planets that are known to reside in wide binaries, we found that they are statistically more eccentric than planets around isolated stars like our Sun. "

The researchers believe this is a telltale signature of past planetary scattering events, and that those with eccentric orbits are often interpreted to be the survivors of system-wide instabilities.

"The eccentric planetary orbits seen in these systems are essentially scars from past disruptions caused by the companion star," said Raymond.

The researchers note that this observational signature could only be reproduced well when they assumed that the typical planetary system extends from its host star as much as 10 times the distance between the Earth and the Sun. Otherwise, the planetary system is too compact to be affected by even a stellar companion on a very eccentric orbit.

"Recently, planets orbiting at wide distances around their host stars have

been directly imaged. Our work predicts that such planets are common but have so far gone largely undetected," says Duncan.

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