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Out of Flatland: Orbits Are Askew in a Nearby Planetary System

Two massive objects orbiting the star Upsilon Andromedae are well out of alignment

By John Matson

MIAMI—The more we learn about planetary systems throughout the galaxy, the more our own solar system appears to be rather unique. A research group measured the orbital tilt of two large objects circling the star Upsilon Andromedae, some 44 light-years away, finding that the two orbits are out of alignment by about 30 degrees. In contrast, the planets of our own solar system—and especially the massive ones—hew closely to a common orbital plane. The researchers announced their finding, published in the June 1 issue of *The Astrophysical Journal*, on Monday at the semiannual meeting of the American Astronomical Society being held here this week.

"This is the first time we've measured the inclination of multiple planets in a system, and it's not flat," said lead study author Barbara McArthur, a research scientist at the University of Texas at Austin.

The Upsilon Andromedae system contains at least three planets, the first and smallest of which was discovered in 1996. When the more massive second and third planets were found in 1999, Upsilon Andromedae became the first sunlike star known to host a multiple-planet system. It is the orbits of those two objects, which orbit the star at greater distances than their smaller counterpart, that McArthur and her colleagues were able to measure in the new research. McArthur's group supplemented a wealth of data from ground-based observatories with precision astrometric measurements made by the Hubble Space Telescope. Hubble's astrometry instruments track the position of a star on the sky, and are sensitive enough to detect the deflection of a star induced by the gravitational pull of its orbiting planets.

When combined with ground-based radial velocity measurements, which determine how much the same orbital motion pulls the star closer to and farther from Earth, astrometry produces a fairly complete picture of an object's physical and orbital parameters. In this case, the astrometric measurements of the two objects yielded a few surprises: For instance, what was thought to be the larger of the two planets turned out to be less massive than its neighbor. And what was thought to be the smaller planet turned out to be so massive that, by a strict mass-based definition, it qualifies as a sort of failed star known as a brown dwarf. McArthur said she prefers to think of it as a "super Jupiter," because in all likelihood it formed like a planet, not like a star.

But perhaps the greatest surprise is how a detailed study of a planetary system revealed the same kind of diversity in large-scale structures that astronomers are finding among individual planets. "I'm here to tell you that we're not in Kansas anymore, as far as solar systems go," McArthur said. The implication is that in modeling the dynamics of extrasolar planetary systems, astronomers and planetary scientists can no longer assume that the orbits of multiple planets share a common plane.

McArthur said that the Upsilon Andromedae system could have started out similar to our own solar system, only to be disrupted later on by any number of mechanisms. The dynamical ejection of a former planet from the system might have an effect, as might a close passage by the star's binary companion, Upsilon Andromedae B. Or collisions among protoplanets early in the system's formation may have sent one or more of the objects careening off its original path.

Astrophysicist Philip Armitage of the University of Colorado at Boulder, who did not contribute to the new research, said that individual tilted planets have been found before, but their tilt had only been assessed in relation to the rotation axis of their host star, not in relation to any fellow planets. The finding of misaligned objects possibly resulting from collisions and ejections in the Upsilon Andromedae system, he said, supports the theory that "forming planetary systems are often overcrowded, if you like."

Fritz Benedict, a study co-author and a colleague of McArthur's at the University of Texas, said that although there are not many more known planetary systems close enough for Hubble to examine astrometrically, by surveying all of them astronomers may get a better sense of how typical our solar system really is. "We have four others that we're working on, and those are the only ones that we have a chance at with Hubble," Benedict said. With the addition of the solar system and now Upsilon Andromedae, that makes six planetary systems whose orbital inclinations can conceivably be measured, and Benedict said that data on the rest of the group could be in hand within a year and a half.

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