The impossible siblings

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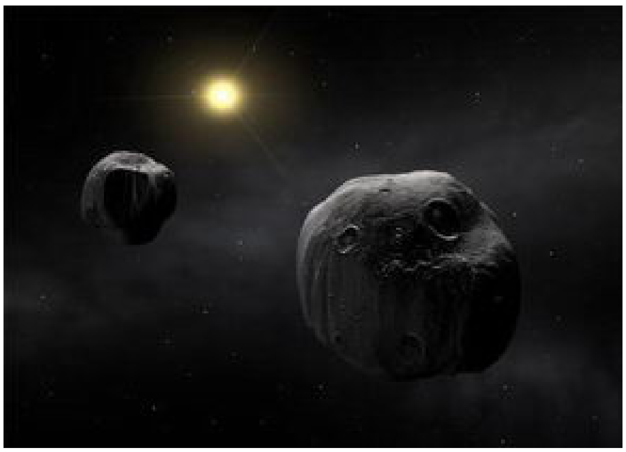

Artist&acutes impression of the double asteroid Antiope. Both components are shown to have a quasi-spherical shape. Credit: ESO

Combining precise observations obtained by ESO's Very Large Telescope with those gathered by a network of smaller telescopes, astronomers have described in unprecedented detail the double asteroid Antiope, which is shown to be a pair of rubble-pile chunks of material, of about the same size, whirling around one another in a perpetual pas de deux. The two components are egg-shaped despite their very small sizes.

The asteroid (90) Antiope was discovered in 1866 by Robert Luther from Dusseldorf, Germany. The 90th asteroid ever discovered, its name comes from Greek mythology. In 2000, William Merline and his collaborators found that the asteroid was composed of two similarly-sized components, making it a truly 'double' asteroid, one of the very first of this kind in the main belt of asteroids that lies between the orbits of Mars and Jupiter.

"The way double asteroids have formed in the main belt is still unclear," says Pascal Descamps, from the Paris Observatory and lead-author of the paper presenting the new results. "The Antiope system provides us with a unique opportunity to know more about this class of objects and we decided to study it in detail," he adds.

Descamps, with colleague Franck Marchis from the University of California at Berkeley, USA, therefore initiated a large campaign of observations for more than two and a half years starting in January 2003. They used the NACO instrument on ESO's Very Large Telescope at Cerro Paranal for the larger part, while using one of the Keck telescopes for some additional observations in 2005.

NACO allows the astronomers to perform adaptive optics observations, providing images that are mostly free from the blurring effect of the atmosphere. With these, it was always possible to separate clearly the two components of the Antiope system, thereby obtaining a large set of very precise measurements of their positions.

"With this unique set of data, we could determine with utmost precision the course of the two pieces of cosmic rock as they turn around each other," says Marchis. "We found that the two objects are separated by 171 km, and that they perform their celestial dance in 16.5 hours. In fact, we now know this orbital period with a precision of better than half a second."

With the orbit determined, the astronomers could derive the total mass of the system: 828 millions million tons, and found the two objects were rotating around their own axes at the same speed as they orbit each other. Thus, in the same way than the Moon does to the Earth, they always present to each other the same side (something astronomers call 'tidal locking'). Moreover, the two asteroids rotate in the same plane as they orbit each other.

The adaptive optics observations could, however, never resolve the shape of the individual components as they are too small. "But with the new orbit, we could precisely predict that from the end of May to the end of November 2005 the system would present eclipses and occultations," says Marchis. "Such 'mutual events' are unique opportunities to learn a great deal about this double asteroid."

The astronomers invited observers around the world to turn their eyes on the asteroid pair to measure the drops in brightness resulting from the predicted events. Over the six-month period, amateurs and professionals from as far afield as Brazil, Chile, France, Réunion Island, South Africa, and the USA, observed repeated occultations as well as shadows passing over one of the pair.

With this new data, Descamps, Marchis and their team, found enough evidence that the two mountain-like chunks of material forming the Antiope system have the shape of ellipsoids, that is, slightly deformed spheres, almost similar in size: 93.0 x 87.0 x 83.6 km and 89.4 x 82.8 x 79.6 km, respectively. Each asteroid in the pair is thus roughly the size of a large city.

Perhaps the most astonishing result is the fact that the two components have a shape close to the one predicted by the French scientist Edouard Roche in 1849 for self-gravitating, rotating fluid objects orbiting each other and tidally locked.

Of course, the asteroids are not gaseous nor liquids, they are solids, but their internal structure must be so loose that their bodies can readjust themselves due to the gravitational influence of the companion.

The scientists were also able to derive the density of the objects, only a quarter higher than the density of water. This means the asteroids are very porous, having 30 percent empty space, and thereby suggesting a rubble-pile structure. This structure could explain why it was easier for the asteroids to reach equilibrium shapes, while being so small.

"Despite this intensive study, the origin of this unique doublet still remains a mystery," says Descamps. "The formation of such a large double system is an improbable event and represents a formidable challenge to theory. One possibility is that a parent body was spun up so much that it took the shape of an apple core, then split into two similar-sized pieces."

Source: European Southern Observatory

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