Novel calculations peg age of 'baby' asteroid

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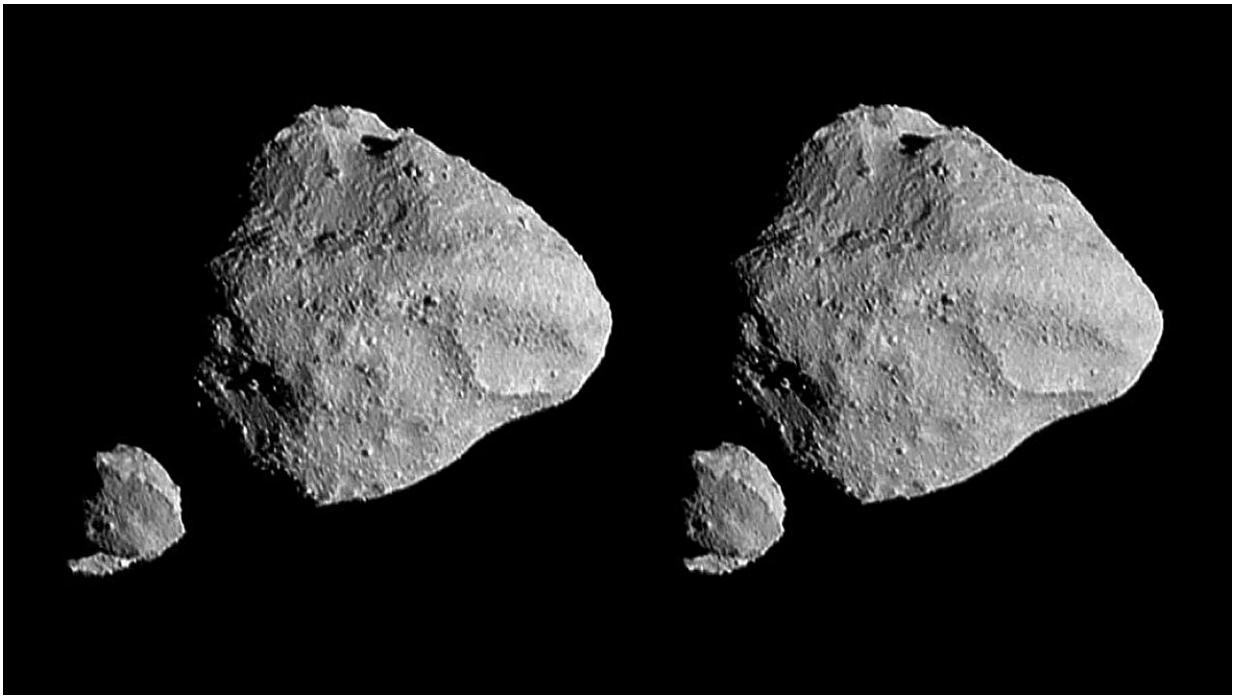

A pair of stereoscopic images of the asteroid Dinkinesh and Selam created with data collected by the L'LORRI camera on NASA's Lucy spacecraft in the minutes around closest approach on Nov. 1, 2023. Credit: NASA/Goddard/SwRI/Johns Hopkins APL/NOIRLab for the original images/Brian May/Claudia Manzoni for stereo processing of the images

An asteroid dubbed "Lucy's baby" after a NASA spacecraft discovered it is orbiting another asteroid last November is,, in fact,, a solar system toddler—just 2–3 million years old, a Cornell-led research team estimates using novel statistical calculations.

The team derived the age of Selam, a "moonlet" circling the small asteroid Dinkinesh in the main asteroid belt between Mars and Jupiter, based only on dynamics or how the pair moves in space. Their calculation agrees with one by NASA's Lucy mission based on an analysis of surface craters, the more traditional method for dating asteroids.

The new method complements that work and has some advantages: It doesn't require an expensive spacecraft to capture close-up images, could be more accurate in cases where asteroid surfaces have undergone recent changes, and can be applied to the secondary bodies in dozens of other known binary systems, which account for 15% of near-Earth asteroids, the researchers said.

"Finding the ages of asteroids is important to understanding them, and this one is remarkably young when compared to the age of the solar system, meaning it formed somewhat recently," said Colby Merrill, a doctoral student in the field of aerospace engineering. "Obtaining the age of this one body can help us to understand the population as a whole."

Merrill is the first author of "Age of (152830) Dinkinesh-Selam Constrained by Secular Tidal-BYORP Theory," published in *Astronomy & Astrophysics* with co-authors Alexia Kubas, a doctoral student in the field of astronomy and space sciences; Alex Meyer, a doctoral candidate at the University of Colorado, Boulder; and Sabina Raducan, a postdoctoral researcher at the University of Bern in Switzerland.

Merrill, a dynamics expert who was part of NASA's Double Asteroid Redirection Test (DART) mission, which in 2022 crashed a spacecraft into the moonlet Dimorphos, was watching closely when the Lucy spacecraft flew by Dinkinesh on Nov. 1, 2023, and unexpectedly found Selam.

The latter turned out to be "an extraordinarily unique and complex body," Merrill said—a so-called "contact binary" consisting of two lobes that are essentially rubble piles stuck together and the first of its kind seen orbiting another asteroid.

Merrill and Kubas immediately began modeling the system as a final project for their "Physics of the Planets" course taught by Philip Nicholson, professor of astronomy at the College of Arts and Sciences (A&S).

Binary asteroids are dynamically complex and fascinating objects that are engaged in a sort of tug of war, the researchers said. Gravity acting on the objects causes them to bulge physically and results in tides, which slowly reduce the system's energy. Meanwhile, the sun's radiation also alters the binary system's energy with an effect termed the binary Yarkovsky-O'Keefe-Radzievskii-Paddack (BYORP) effect.

Eventually, the system will reach an equilibrium where tides and BYORP are equally strong—a stalemate in the tug of war.

Assuming those forces were in equilibrium and plugging in asteroid data shared publicly by the Lucy mission, the researchers calculated how long it would have taken for Selam to reach its current state after forming from surface material ejected by a rapidly spinning Dinkinesh. Along the way, the team said it improved upon preexisting equations that assumed both bodies were equally dense and ignored the secondary body's mass.

Running roughly 1 million calculations with varying parameters, the results produced a median age for Selam of 3 million years old, with 2 million being the most likely result.

Determining Selam's age advances comparisons with Didymos and

Dimorphos, the even younger system targeted by NASA's DART mission, and adds to an understanding that binary systems are being created continuously. The researchers now hope to apply their new aging method to other binary systems where dynamics have been well characterized, even without close flybys.

"Used in tandem with crater counting, this method could help better constrain a system's age," Kubas said. "If we use two methods and they agree with each other, we can be more confident that we're getting a meaningful age that describes the current state of the system."

The calculations suggest the asteroid Selam is younger than the human-ancestor fossil on Earth for which it is named—the skeletal remains of a 3-year-old girl found in Ethiopia, determined to be 3.3 million years old. Selam means "peace" in Ethiopia's language and has also been nicknamed "Lucy's baby," referring to famous human-ancestor remains found in 1974 and dubbed Lucy or Dinkinesh. The NASA mission named for Lucy is on its way to studying Trojan asteroids in Jupiter's orbit in 2027.

More information: C. C. Merrill et al, Age of (152830) Dinkinesh I Selam constrained by secular tidal-BYORP theory, *Astronomy & Astrophysics* (2024). DOI: 10.1051/0004-6361/202449716

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