

CENTRIPETAL FORCE FROM GRAVITY

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Chasing Shadows for a Glimpse of a Tiny World Beyond Pluto



An artist's rendering of one possible version of the Kuiper belt **object 2014 MU69**, the next flyby target for NASA's New Horizons mission.

This summer, scientists crisscrossed two oceans, braved wind and cold and deployed two dozen telescopes — all for five blinks of starlight that lasted a second or less. For the team working with [NASA's New Horizons spacecraft](#), which made [a spectacular flyby of Pluto](#) two years ago, those smidgens of data provide intriguing hints about the spacecraft's next destination, a distant frozen world that is believed to be a pristine, undisturbed fragment from the earliest days of the solar system. New Horizons [will fly past it on Jan. 1, 2019](#). But the object is so far away — **a billion miles beyond Pluto — and so small — no more than 20 miles wide** — that almost nothing was known about it. From the five blinks, obtained with exhausting effort, scientists now know that it has an odd shape. Instead of round like a ball it appears to be more like a long, skinny potato — or maybe two objects in close orbit around each other, possibly even touching.



A rendering of another possible version of the object.

INTRODUCTION: Gravity keeps all objects in orbit about the sun: planets, meteors, comets, & objects like MU69 in this article. $GmM/R^2 = m v^2/R$, where $v = R \omega = R2\pi f = 2\pi R/T$
 $GM/R^2 = [4\pi^2 R^2/T^2] /R$

$M = [4\pi^2/G] [R^3/T^2]$ Kepler's 3rd. Law

NASA has found MU69's period of orbit to be 296 years. Also, NASA confirms MU69's semimajor axis (radius of orbit R) to be 44.387 AU (astronomical unit = distance from center of earth to center of sun = 1.5×10^{11} meters = 93,000,000 miles).

QUESTIONS: (a) Find R of MU69 in meters?, (b) Confirm R of MU69 is as stated below close to 4 billion miles. In other words, convert 44.387 AU = R to miles?, (c) Find period T = 296 years in seconds?, (d) Using Kepler's 3rd. law, find mass of our sun using R & T of MU69 ?, (e) How close did (d) come to NASA mass of our sun? **Continued below**

HINTS: G = gravitational constant = $6.67 \times 10^{-11} \text{ N m}^2/\text{kg}^2$
365 days/yr., 24 hrs./day, 3600 seconds/hr.,

ANSWERS: (a) $R = 6.66 \times 10^{12} \text{ m.}$, (b) $R = \sim 4.127 \times 10^9 \text{ miles}$,
(c) $T = 9.335 \times 10^9 \text{ seconds}$, (d) $M_{\text{SUN}} = 2.006 \times 10^{30} \text{ kg.}$,
(e) NASA says $M_{\text{SUN}} = 2.0 \times 10^{30} \text{ kg.}$, thus, the verification is very close using the period T and radius R of MU69's orbit.

While Pluto is the biggest object in the ring of icy debris beyond Neptune known as the Kuiper belt, **this object with the designation 2014 MU69 is among the smallest.(((It orbits more than four billion miles from the sun)))**, and it is like a time capsule, promising clues about how the planets formed. Not even the largest, most powerful telescopes on Earth can see it at all. The New Horizons scientists could, however, learn more about it during a few chance moments when a star in the night sky momentarily vanished because MU69 passed in front of it. From the distance to MU69, its speed and how long the star winks out, astronomers can calculate the width of the object. It turned out that a bonanza of three such events, which are known as occultations, were expected to occur within a two-month period this year, on June 3, July 10 and July 17, as MU69 passed in front of three different stars.