The Near Earth Asteroid Photometry and astrometry of 2019 PR2 and 2019 QR6

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Introduction

Who is Dr. Ries?

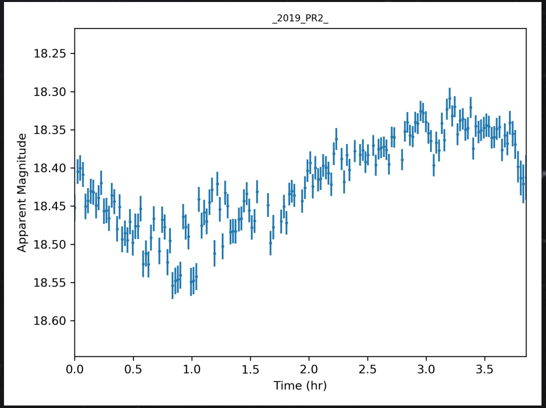
- Judit Györgyey Ries was born in Hungary, and got her B.S. in Astronomy from the Eötvös University in Budapest.
- She came to the US in 1982 and received an M.S. in Aerospace Engineering, in 1992 she received a Ph. D. in Astronomy. She worked with the Mcdonald Observatory lunar laser ranging experiment doing data analysis. In 1997 she joined the the NEO observing program, and started regular observations. In 2012 she took over the program and continued it until 2022. She contributed to assign designations for 792 new NEAs and 79 new NEC. She also determined rotation periods for a dozen NEAs.
- She started Education and Public Outreach work with the Center for Space Research Outreach Team and conducted numerous STEM workshops in the underserved areas of Texas, ranging from 2 to 5 days. She was also working with visually impaired students and TSBVI for 8 years, starting with an HST grant, and continuing with several TSGC grants.
- She was also a lecturer at the University of Texas at Austin for 8 years teaching introductory astronomy courses.

Introduction

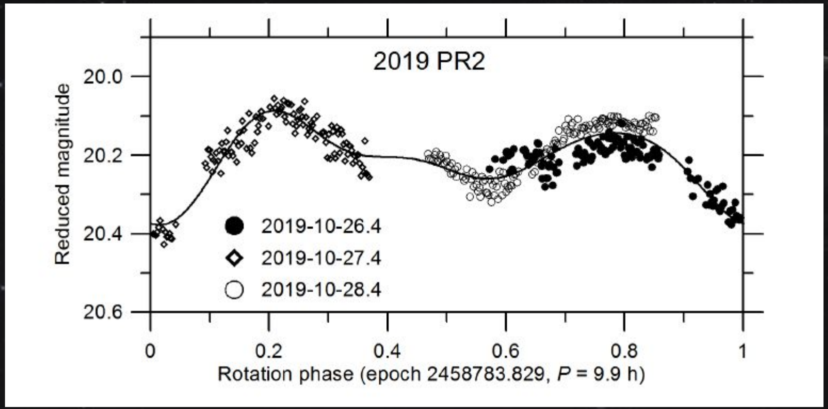
What Work Has she Conducted on the asteroids 2019 PR2 & 2019 QR6?

I was lucky to be at a telescope when observations were needed to nail down the rotation period of 2019 PR2 started by N. Moskowitz at Lowell observatory. It was a recently discovered object, which was fading fast and they needed a large aperture telescope to get strong data, so I took images for 3 nights, resulting in this folded data set. At that time 2019 QR6 was already too faint even for a 2.1m telescope.

Raw light curve



Light curve after orbital effects are removed



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Hypothesis

Because 2019 PR2 and 2019 QR6 (two Near Earth Asteroids) move on very similar orbit and and have similar physical characteristics, these objects could be genetically-related and formed in a fairly recent separation event.

Background Information

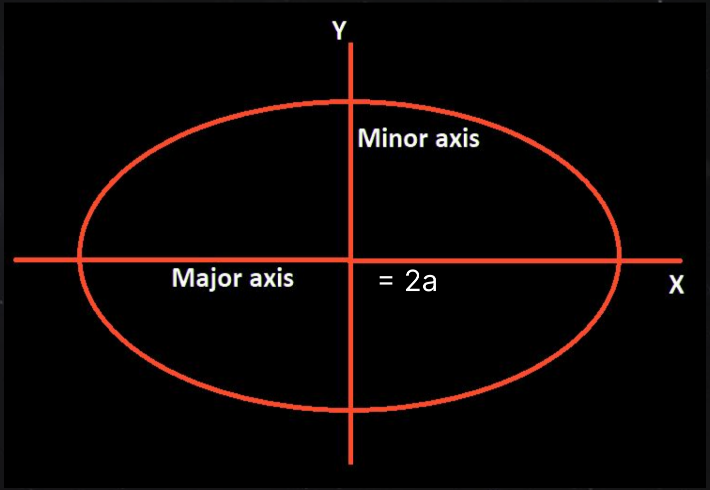
- Astrometry gives the position in terms of right ascension and declination of an object, in this case the asteroids, at the time of the observations
- Allows for computing its orbit at any time
    a. The more time the observations cover, the less uncertainty in the orbit

- More precise orbits allow researchers to go back in time or forward in time to see where the asteroids were/will be
- Photometry gives us physical properties such as rotation period, size, and color
    a. Helps researchers classify the object being observed

The case for being twin Asteroids

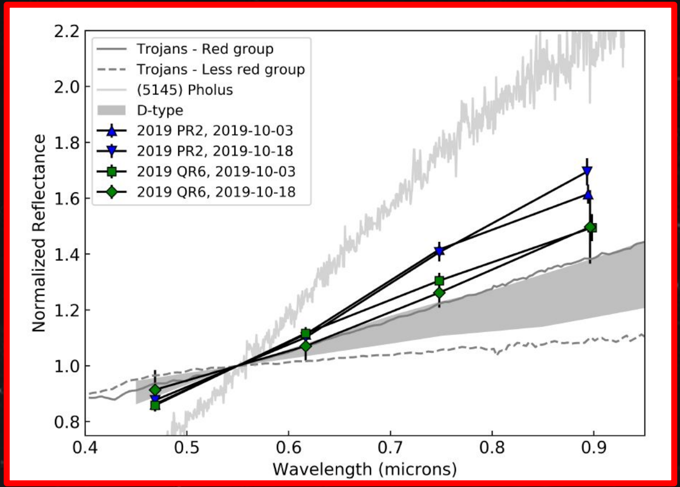
They move on almost identical ellipses:

2019 Pr2: a = 5.7716, e =0.79834, i = 10.9926
2019 Qr6: a = 5.7723, e =0.79837, i = 10.9745



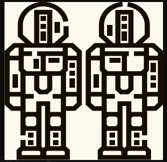
They have very similar colors (spectral type)

They are both very red, redder typical D type

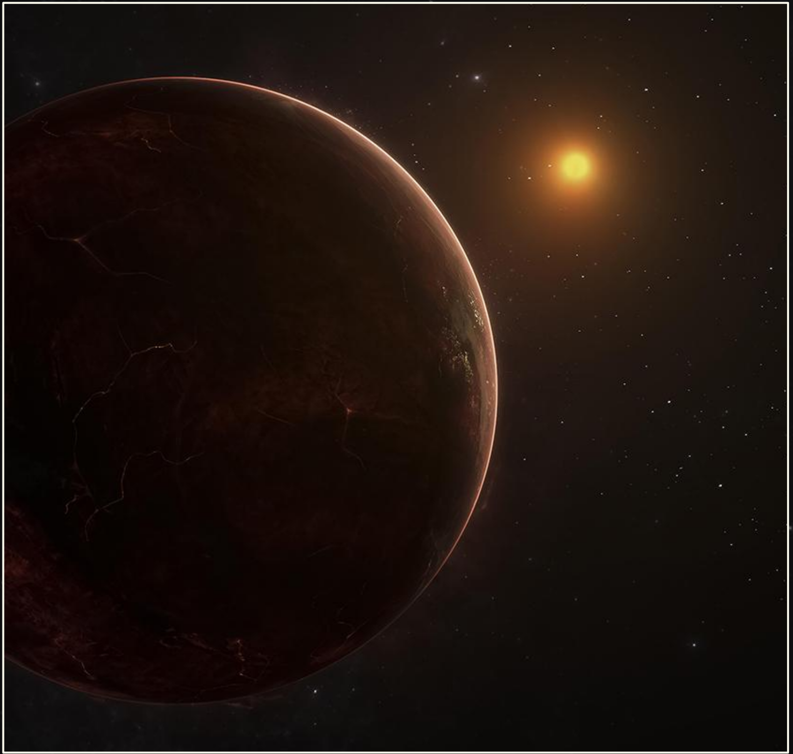


Backwards integration brings them close to each other and Jupiter only if gas emission from the bodies is included in the orbital modelling

Conclusions of research



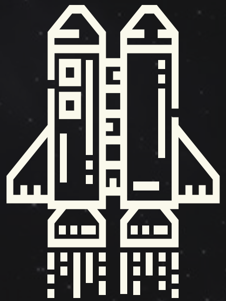
- The asteroids are spectrally similar to D-types, which is rare amongst NEOs (near-earth objects.
- Orbit integrations taking into account gravity and the Yarkovsky effect only did not bring them close to each other in the past.
- The next model assumed quasi-continuous, comet-like activity following separation, suggesting a formation time of 300^{+120}_{-70} years ago.
- Second model assumed short-term activity for up to one heliocentric orbit (~13.9 years) after separation, implying that the pair formed 272±7 years ago
- 2019 PR2 had no activity during its last perihelion passage
- Signifies a common origin that makes these objects the youngest asteroid pair known to date



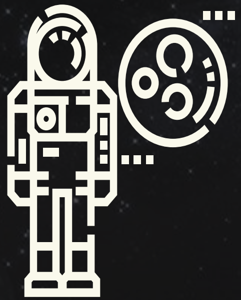
If Jupiter's tidal forces broke the original body into two:

If they are asteroids from the neighborhood of Jupiter: rocky and do not emit gases

Gravitational and Yarkovsky effect cannot make the asteroids into NEAs



If they are cometary in origin: they contain lot of volatiles, and can emit gases



They can become NEAs both by assuming constant low-level emission of gases, or one outburst
However, no activity was detecting at the time of observations (when they were already close to the Sun) making the second scenario more likely

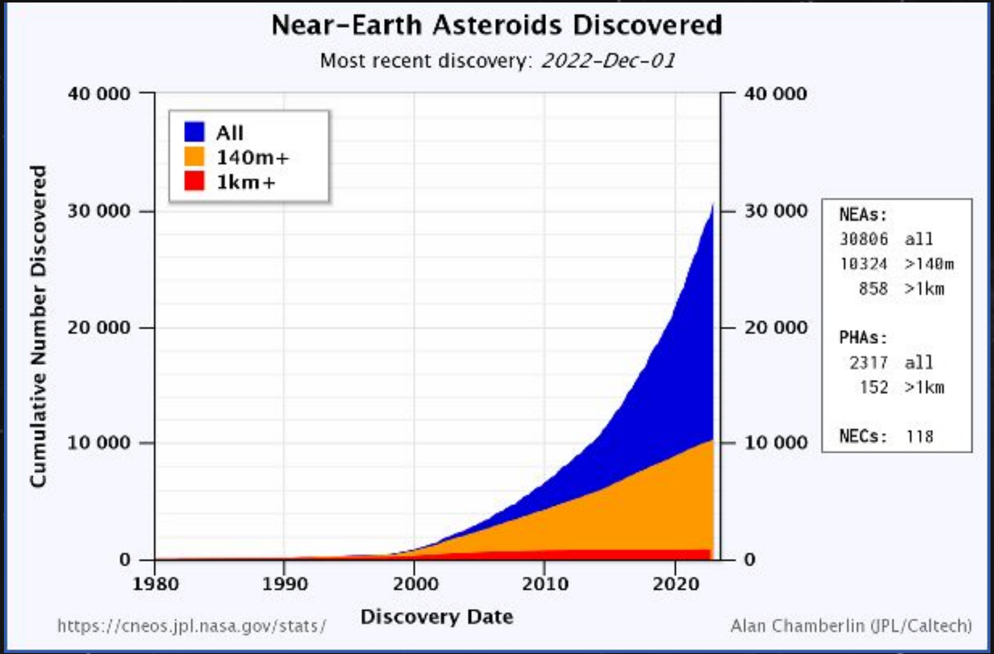
Researching walk-through

Near Earth objects

Near-Earth Objects (NEOs) are comets and asteroids that have been nudged by the gravitational attraction of nearby planets and by non-gravitational effects into orbits that allow them to enter the Earth's neighborhood

Generally, for asteroids anything with perihelion distance less than 1.3 AU

Surveys: Catalina, Pan-Starr, Atlas, NEOWISE, LINEAR



We found about 50% of the estimated total for d > 0.14km

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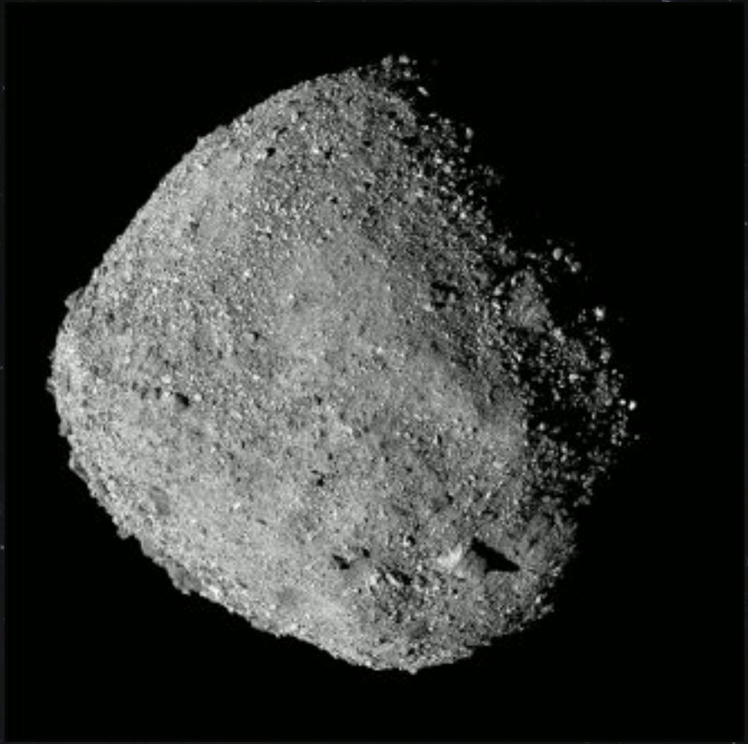
Dimensions:
565m × 535m × 508m

Potentially Hazardous: Large enough, and can get as close as 20 lunar distance.

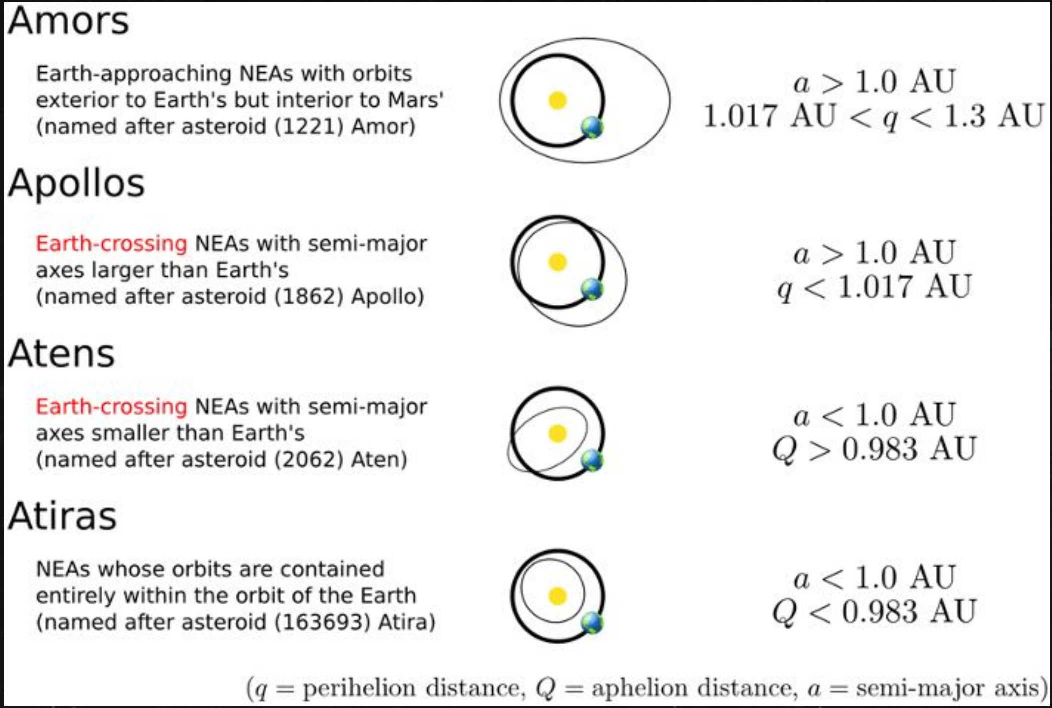
By Osiris Rex December 2018



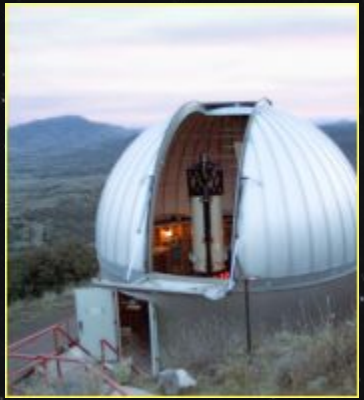
NEA Types

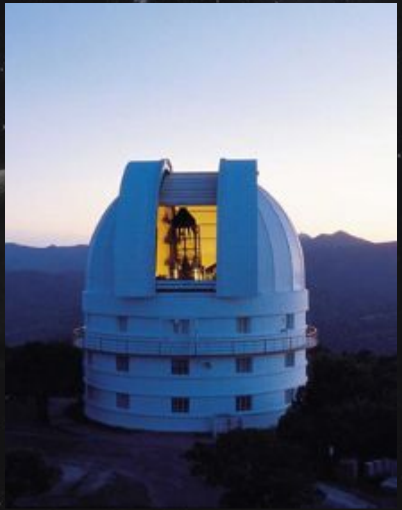
https://minorplanetcenter.net/

https://cneos.jpl.nasa.gov/



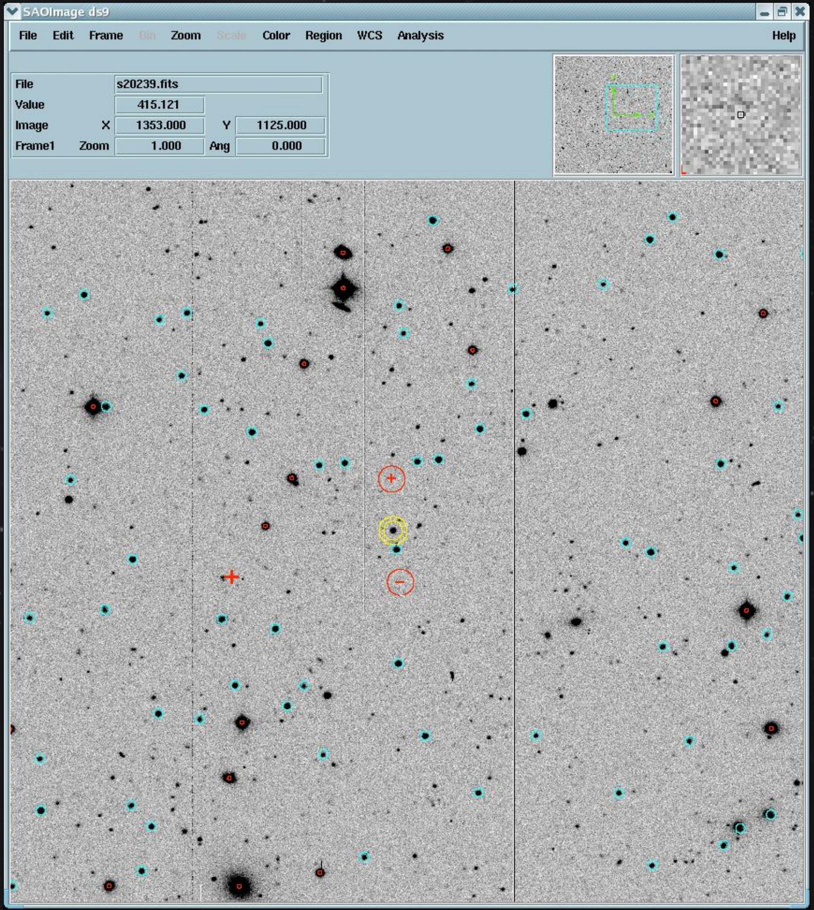
How do you find an Asteroid?





Take minimum three exposures
Mark predicted position and motion
Blink the three images

Astrometry and (relative) Photometry



We need a catalog to calculate the position of the asteroid:

1. Find the reference stars on the image
2. Get their coordinates
3. Based on the coordinates (ξ and η) find the relationship between pixel coordinates, x,y and ξ,η for the whole image

$$\xi = a_1 X + a_2{*}Y + a_3 + a_7{*}\,(X^2 + Y^2)$$

$$\eta = b_1{*}Y + b_2{*}X + b_3 + b_7{*}\,(X^2 + Y^2)$$

4. **Locate the asteroid, and measure its X and Y coordinates**
5. **Using the plate solution calculate the asteroids ξ and η**

For photometry also

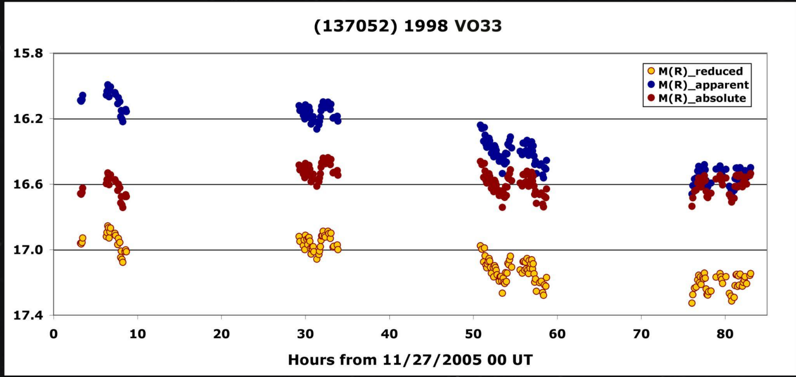
1. Extract the reported magnitudes for the reference stars
2. Find relationship between the plate magnitudes and the catalog magnitudes
3. Measure the asteroids plate magnitude
4. Convert it into catalog magnitudes using the photometric solution

Finishing the photometry

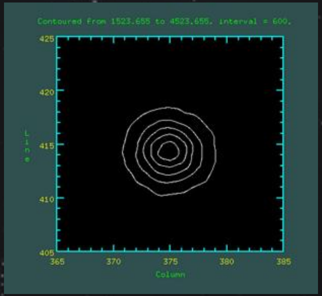
The brightness of an asteroid changes because:

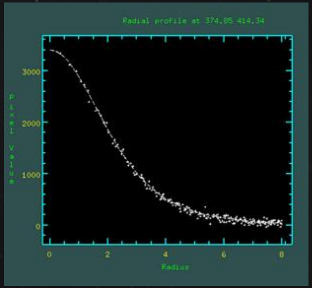
1. The distance from the Sun changes
2. The distance from the Earth changes
3. The viewing phase changes
4. Rotational effect - non-spherical shape and varied surface

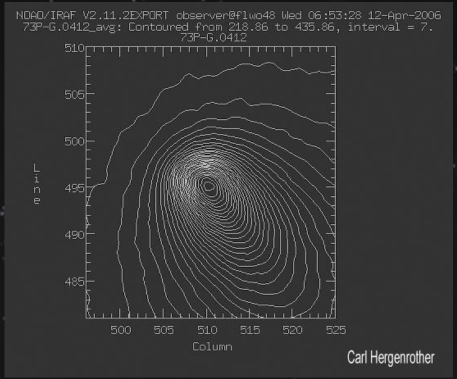
To obtain rotational periods and compare the actual brightness we need to remove 1 - 3

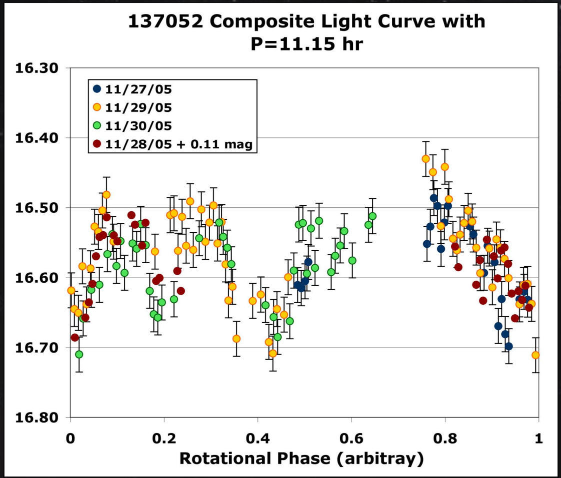


Cometary activity - detection of a tail









Reference: Fatka,P. et al., 2022, Recent formation and likely cometary activity of near-Earth asteroid pair 2019 PR2 – 2019 QR6, MNRAS **510**, No. 4

Does anyone have any questions?

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