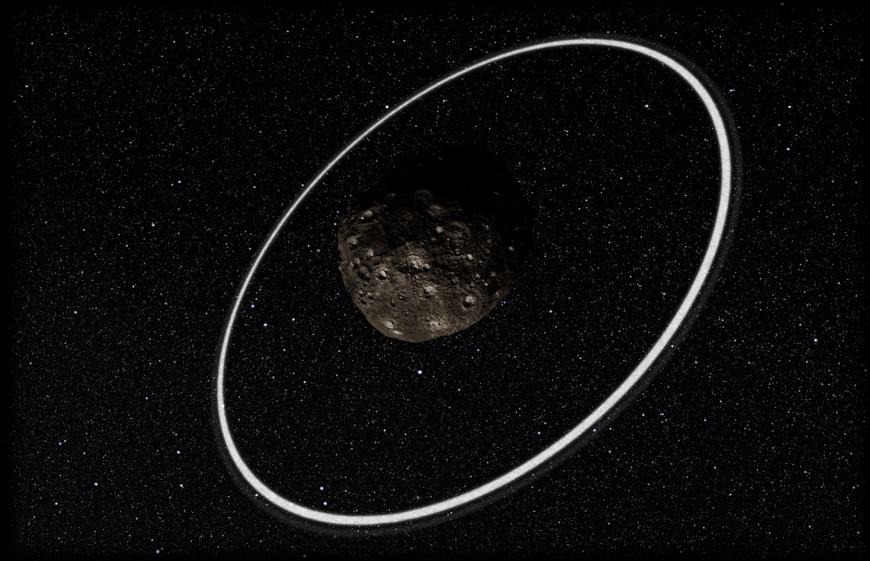
SMALL OUTER SOLAR SYSTEM OBJECTS:

Kuiper Belt Objects → Centaurs → Jupiter-family comets

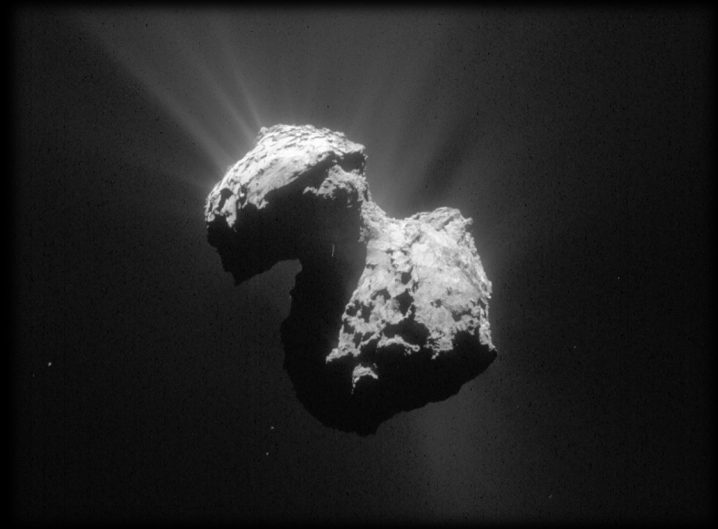
(134340) Pluto

Image Credit: *NASA/Johns Hopkins University Applied Physics Laboratory/Southwest Research Institute/Alex Parker*



(10199) Chariklo
(artist's impression)

Image Credit: *ESO/L. Calçada/M. Kornmesser/Nick Risinger (skysurvey.org)*



67P/Churyumov-Gerasimenko

Image Credit: *ESA/Rosetta/NAVCAM*

COMETARY ACTIVITY:

Jupiter-family comets:

- Activity strongly coupled to heliocentric distance

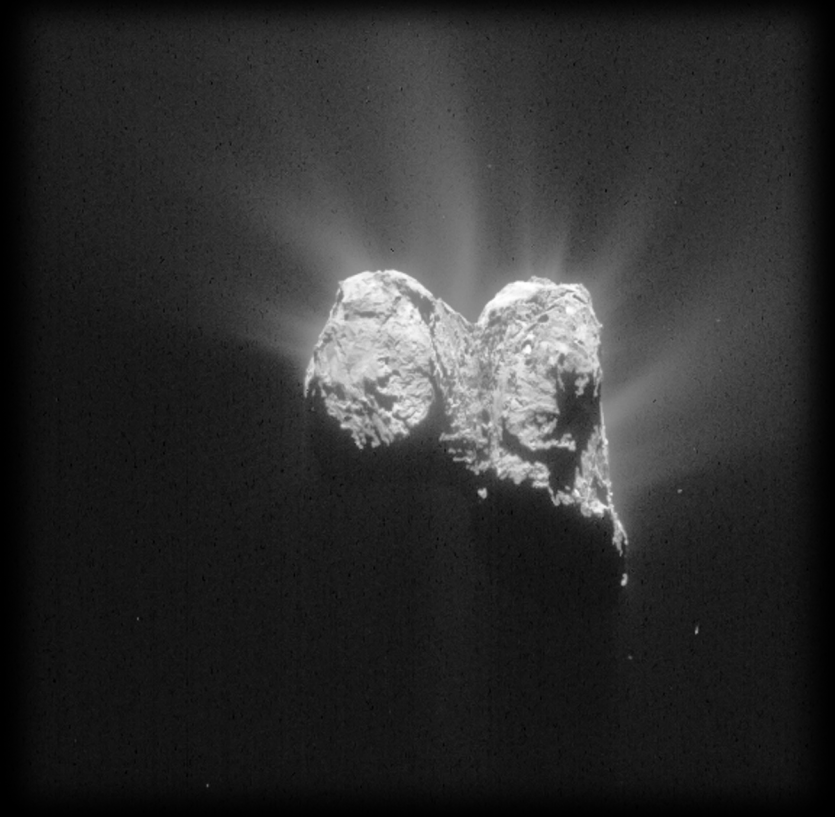


Image Credit: *NASA/JPL-Caltech/UMD*

Centaurs:

- Activity *independent* of heliocentric distance

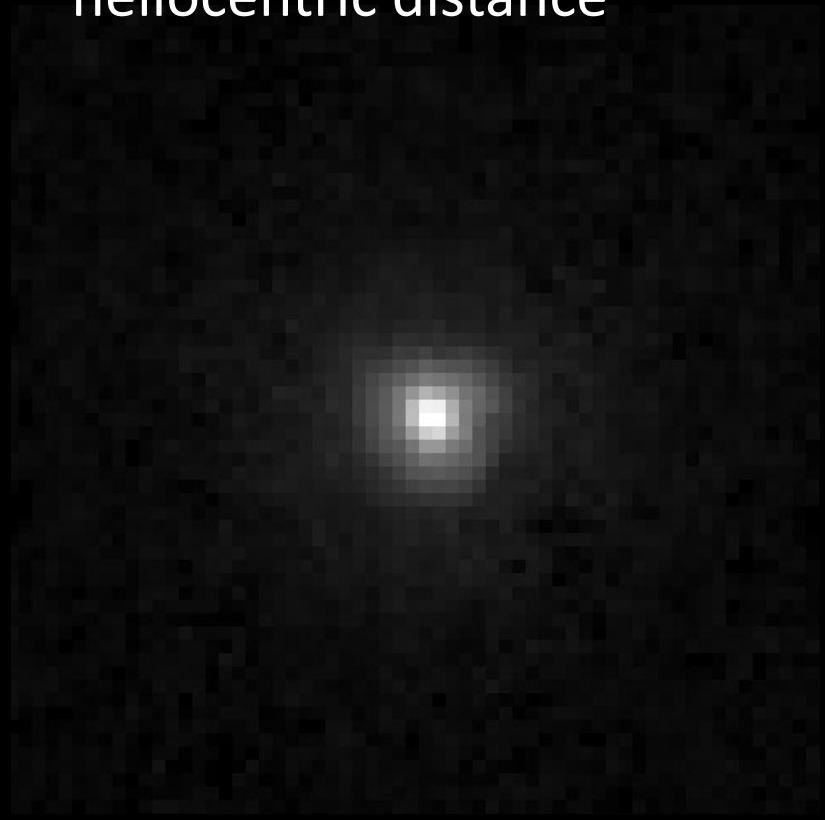


Image Credit: *Hubble Space Telescope/Karen Meech*

PHASE CURVES

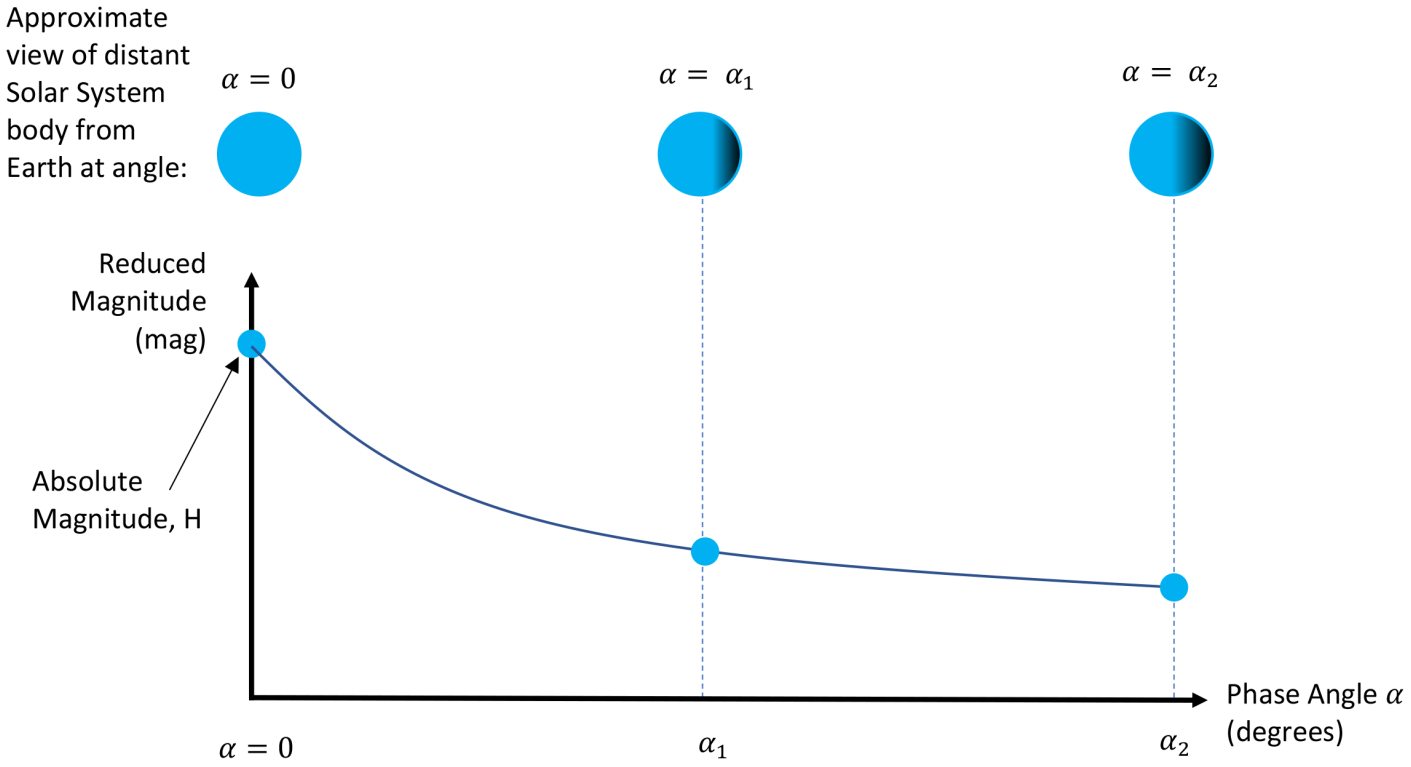
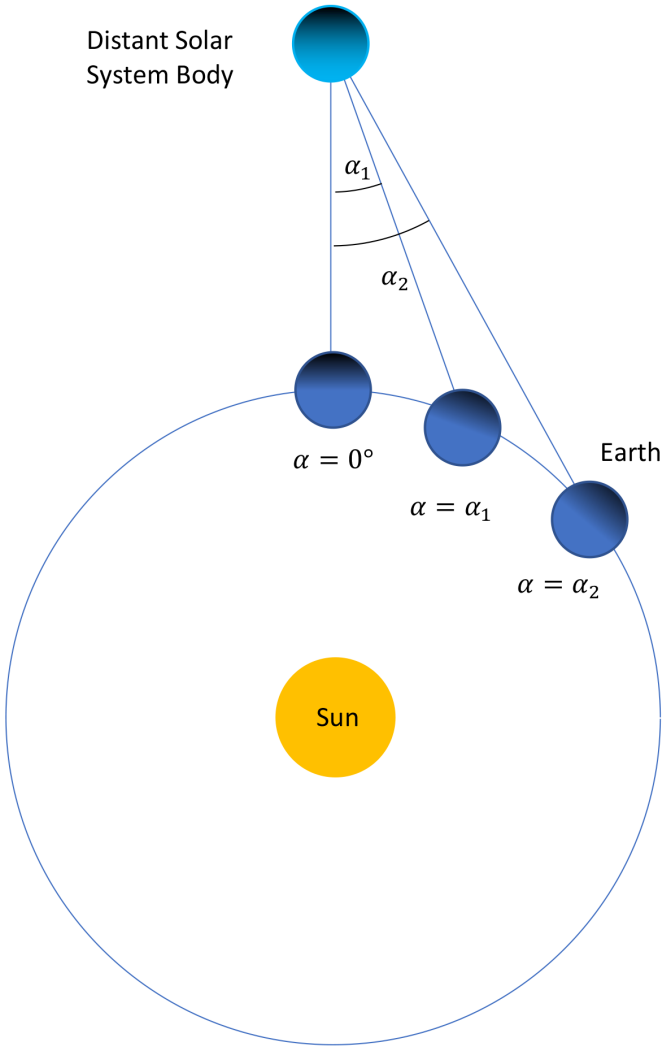


Image Credits: *F. Espenak, @2012*



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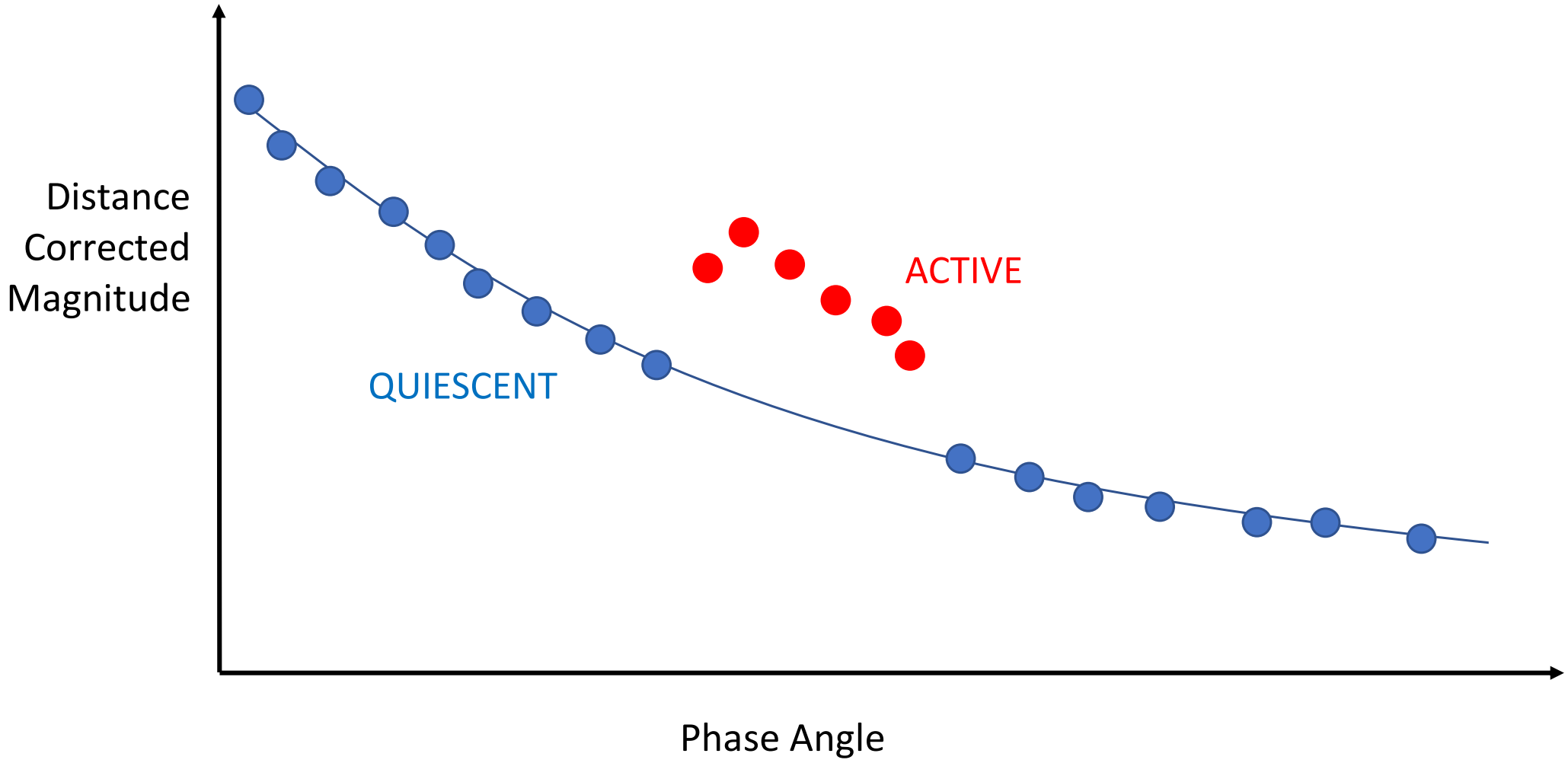

ATLAS

Asteroid Terrestrial-impact Last Alert System

- Wide-field survey (Tonry et al. 2018):
  - Two 0.5-m Schmidt telescopes in Hawai'i, two further installations in South Africa and Chile
  - Limiting magnitude ~19.5
  - Two non-standard filters: cyan (420-650 nm) and orange (560-820 nm)
  - 2-night cadence, four 30s exposures per cycle

Image Credit: *ATLAS*

Near-continuous operation since 2016 – ~5 years of photometry for:

- 7 KBOs
- 4 Centaurs
- 5 JFCs
- 2 'Transition Objects'

OBJECT BRIGHTNESS EQUATION

Data obtained using ATLAS Forced Photometry Server: https://fallingstar-data.com/forcedphot/

$$V(\alpha,r,\Delta) = H + \delta + 5\log_{10}(r\Delta) - 2.5\log_{10}(\phi(\alpha)) + F + A$$

- $V(\alpha,r,\Delta)$: Apparent Magnitude
- H: Absolute Magnitude
- δ: Variability due to rotation
- $5\log_{10}(r\Delta)$: Distance (geocentric and heliocentric)
- $-2.5\log_{10}(\phi(\alpha))$: Phase Angle
- F: Brightening due to background flux
- A: Brightening due to cometary activity

OBJECT BRIGHTNESS EQUATION

Data obtained using ATLAS Forced Photometry Server: https://fallingstar-data.com/forcedphot/

$$V(\alpha,r,\Delta) - 5\log_{10}(r\Delta) = H + \delta - 2.5\log_{10}(\phi(\alpha)) + F + A$$

Reduced Magnitude

Absolute Magnitude

Variability due to rotation

Phase Angle

Brightening due to background flux

Brightening due to cometary activity