The unusual optical dimming and near-infrared brightening of ASASSN-21qj

Exocometary breakup or colliding ice giants?

Ciska Kemper
(ICE-CSIC / ICREA / IEEC)

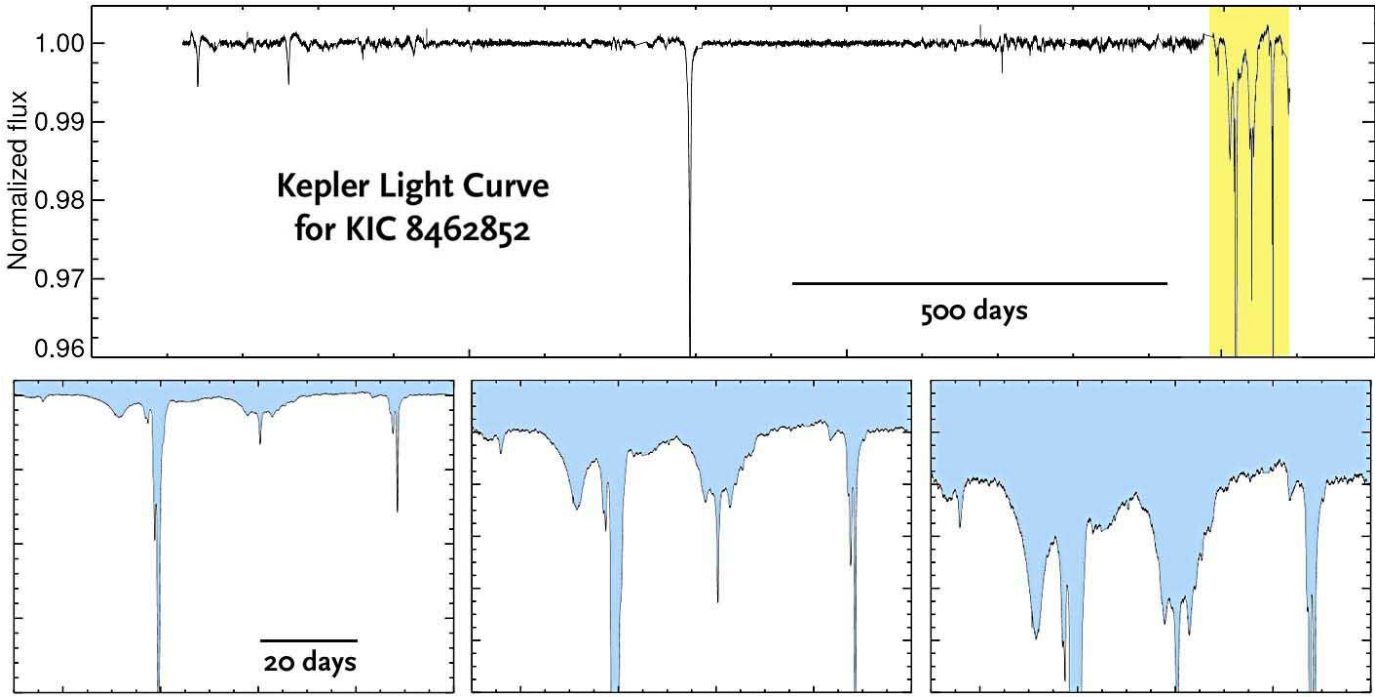
XXXVIII Trobades de la Mediterrània – 6 Nov 2023 – Maó

ICREA

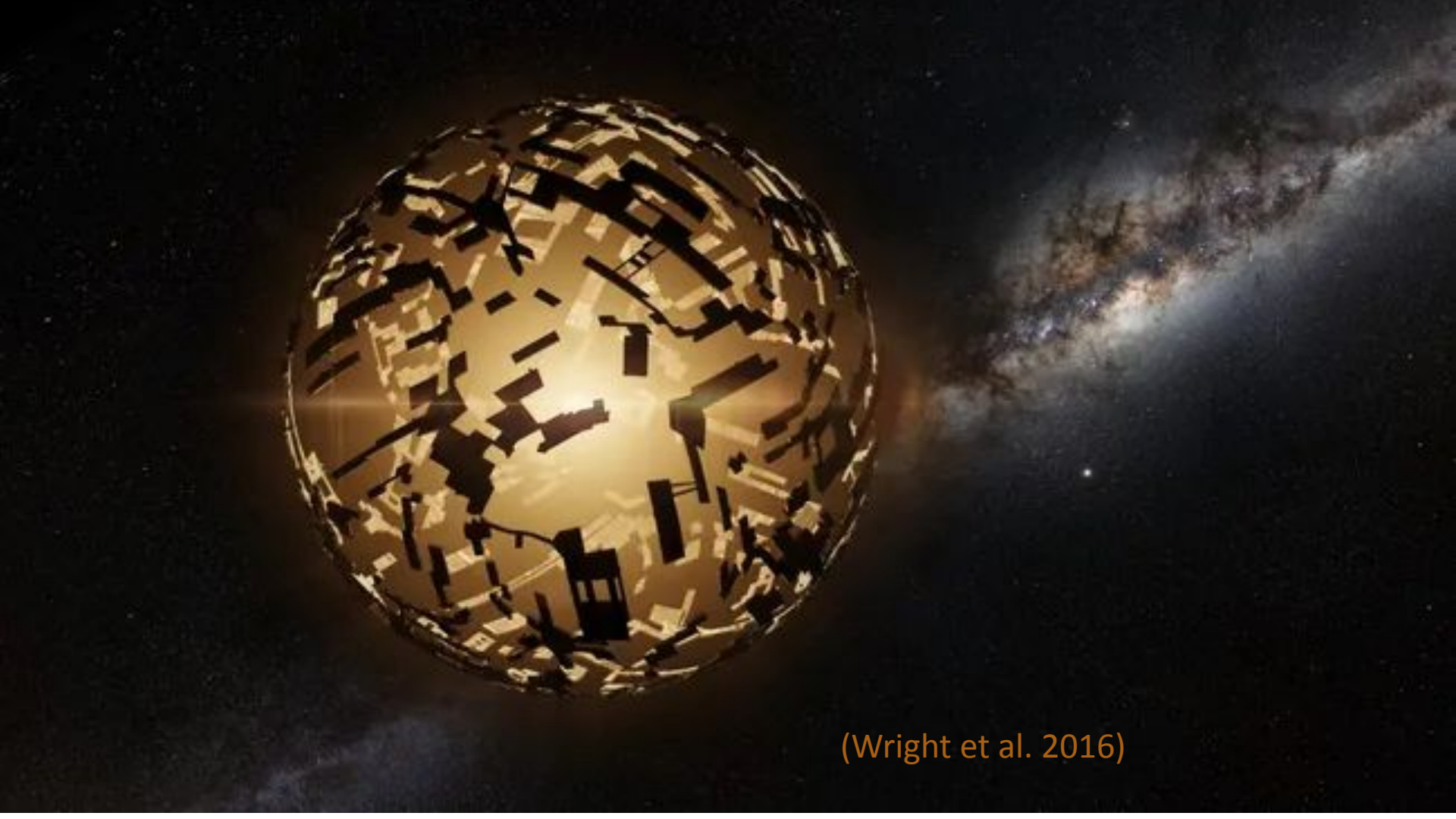
ICE INSTITUT DE CIÈNCIES DE L'ESPAI

CSIC Consejo Superior de Investigaciones Científicas

IEEC



(Boyajian et al. 2016)



(Wright et al. 2016)

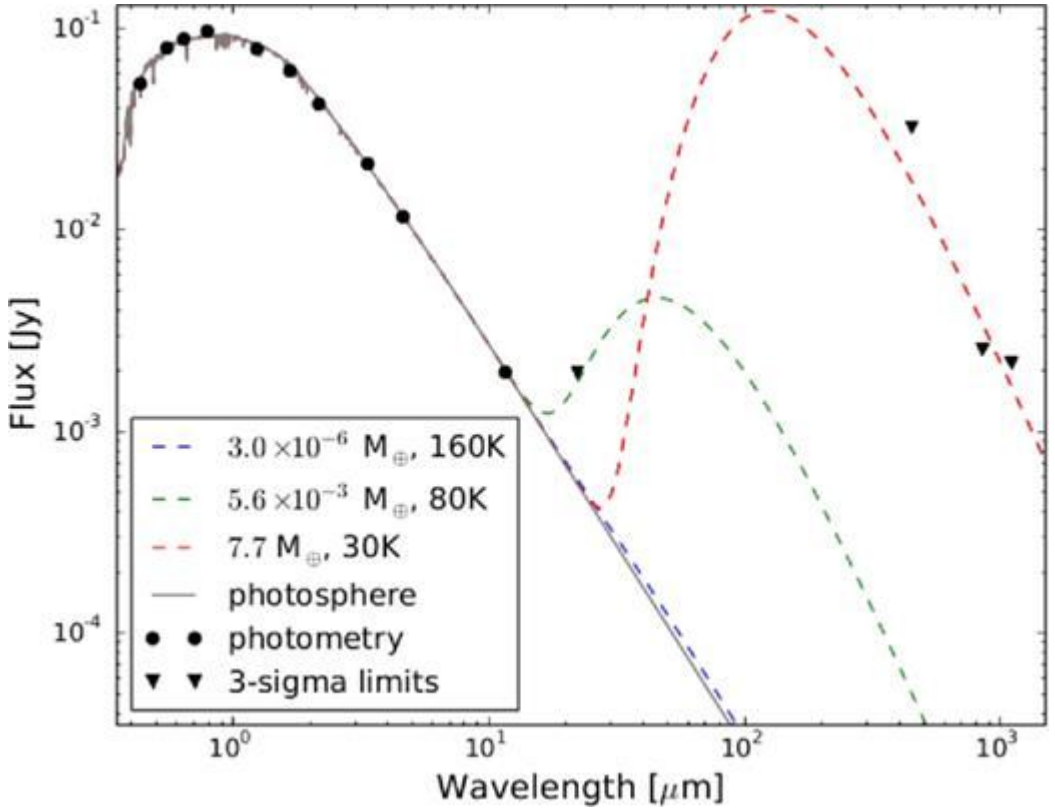
Constraining the dust mass of KIC 8462852

< 10^{-6} $M_\oplus$ within 8 au

< 8 $M_\oplus$ within 200 au

Planetary collision unlikely

Breakup of multiple comets



(Thompson et al. 2016)

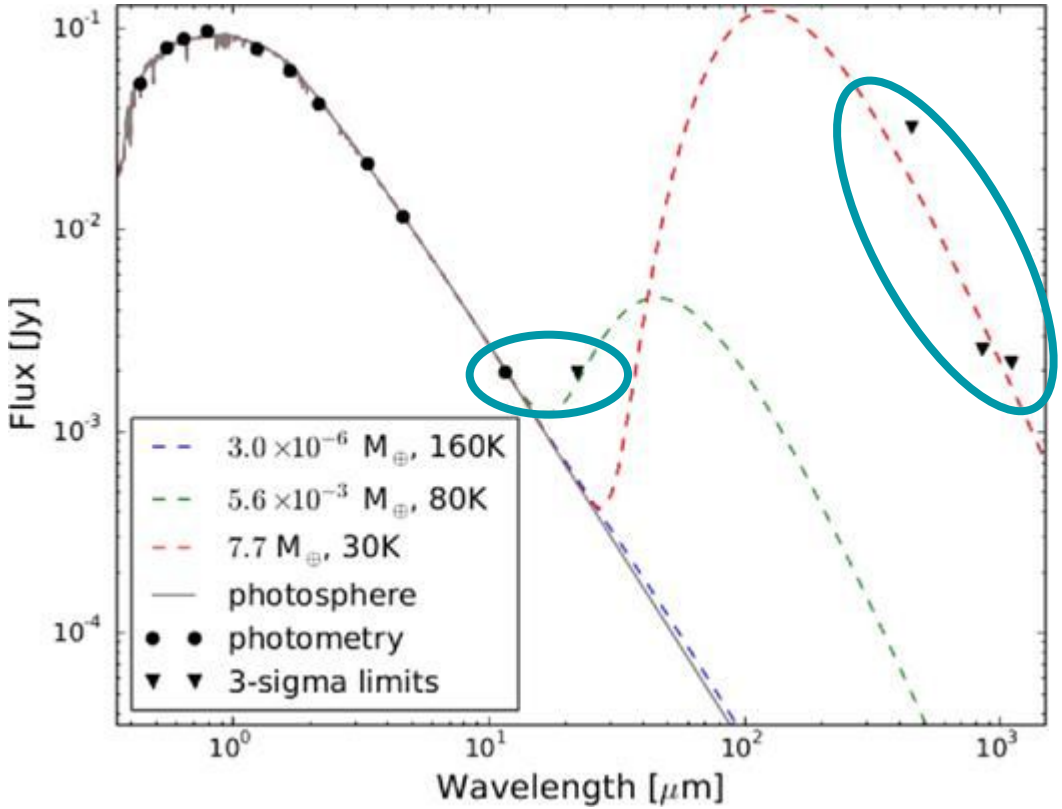
Constraining the dust mass of KIC 8462852

< 10^{-6} $M_\oplus$ within 8 au

< 8 $M_\oplus$ within 200 au

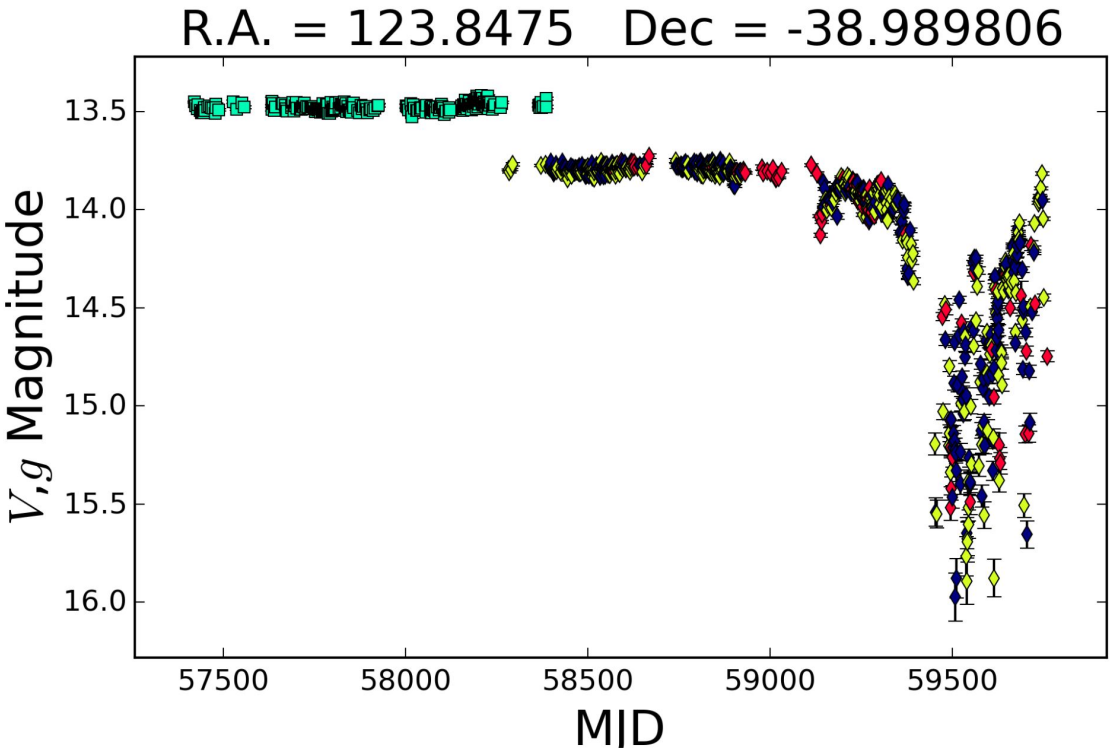
Planetary collision unlikely

Breakup of multiple comets



(Thompson et al. 2016)

ASASSN-21qj



(Rizzo Smith et al. 2021; 2022)

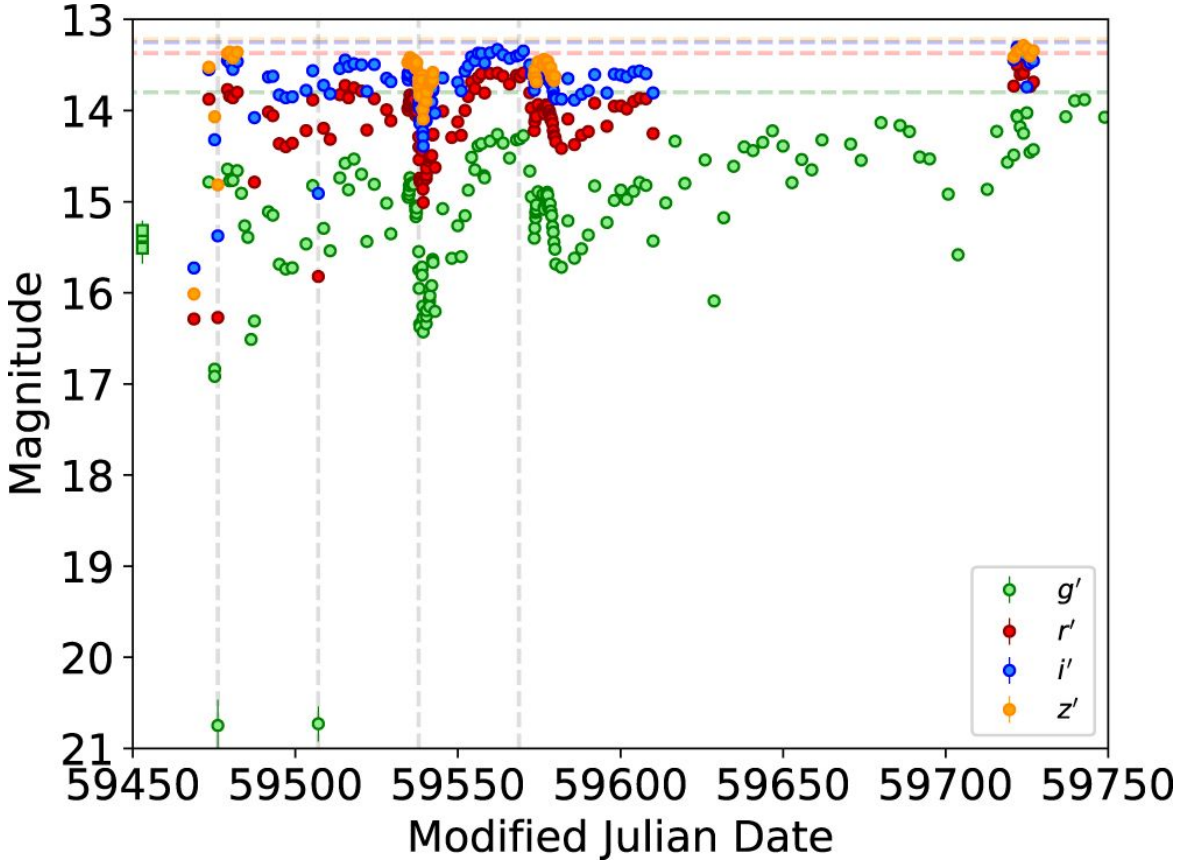
ASASSN-21qj

distance	556 pc
radius	0.977 $R_\odot$
effective temperature	5948 K
mass	0.94 $M_\odot$
luminosity	1.076 $L_\odot$
age	6 Gyr

Additional data

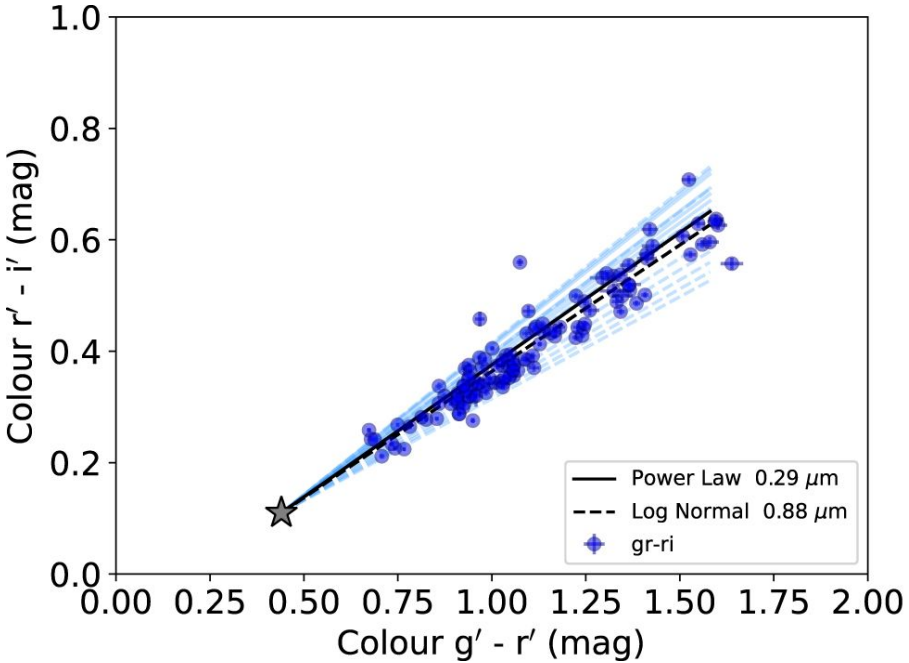
Las Cumbres Observatory Global Telescope data

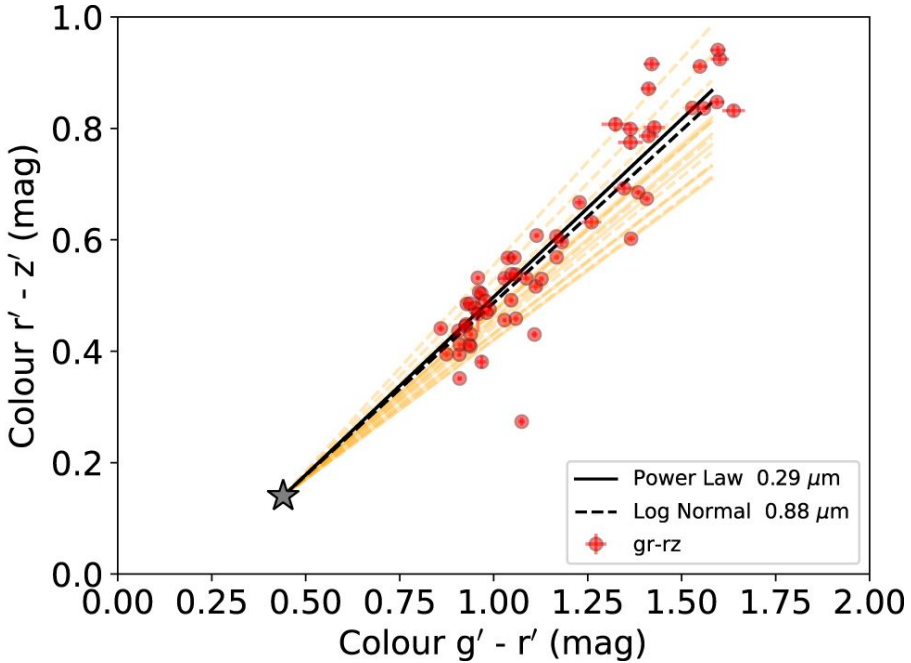
Periodicity of **30.9 days**



(Marshall et al. 2023)

Extinction law consistent with small silicate grains throughout





(Marshall et al. 2023)

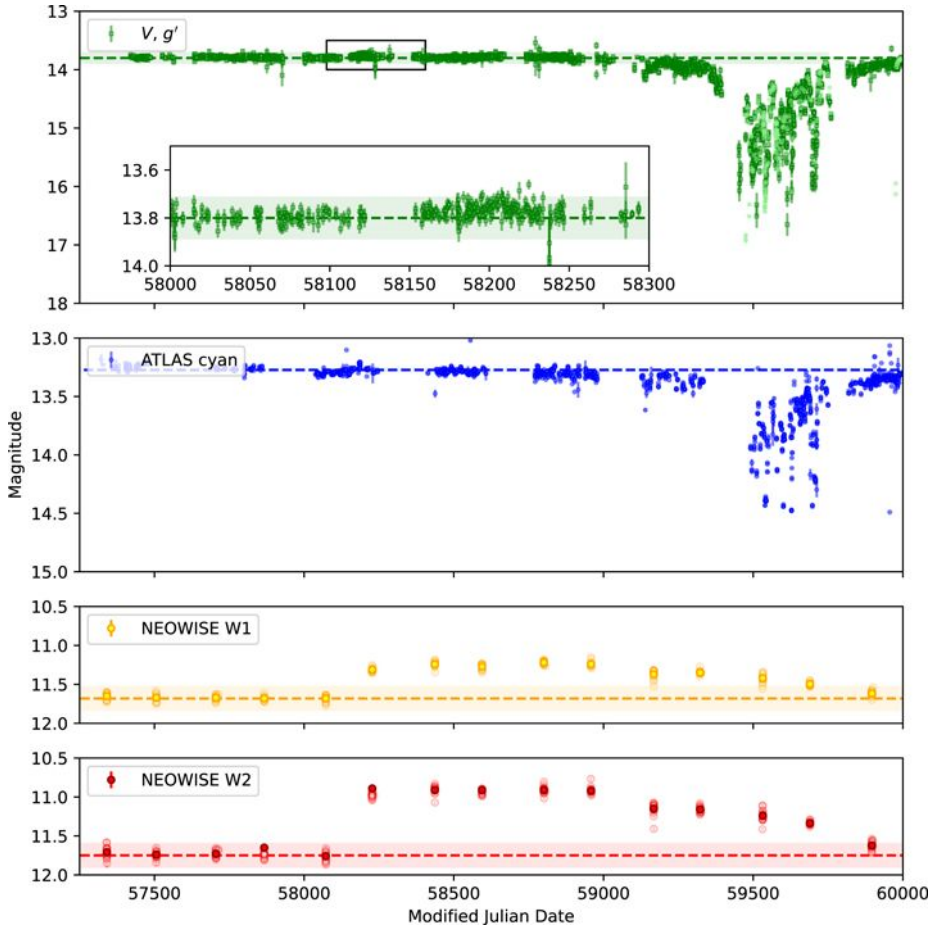
Near-infrared

NEOWISE

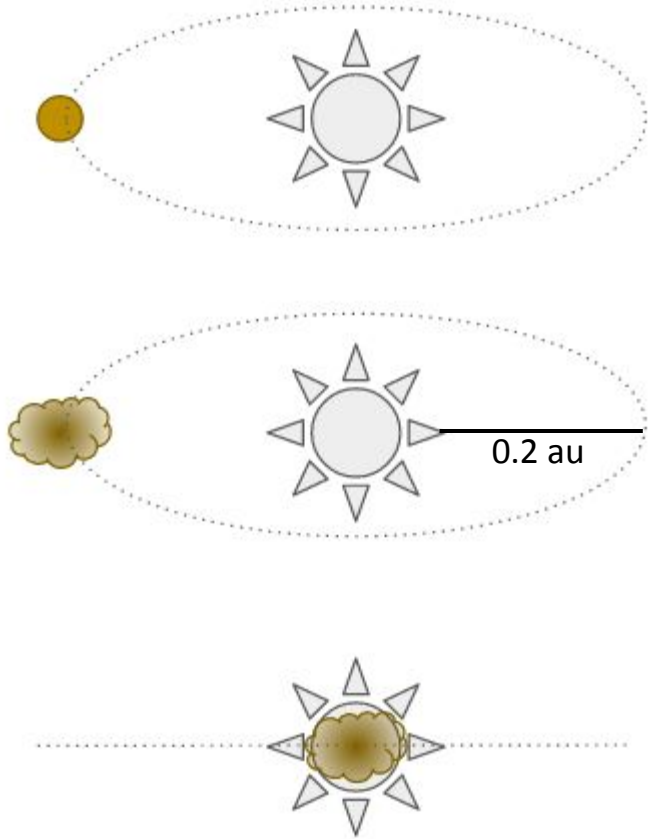
NIR brightening 2.5 year before dimming event

T_{color}: 700-1300 K

NIR excess ends at end of dimming



(Marshall et al. 2023)



(Marshall et al. 2023)

Assumptions

Dimming and near-infrared brightening is caused by the same dust

After 2.5 years cloud moves into sightline

P and T_{dust} are consistent

Dust masses

Total dust mass: > 2×10^{-6} $M_\oplus$

Transiting dust cloud: > 1.5×10^{-9} $M_\oplus$

Comet: ~10^{-10} $M_\oplus$

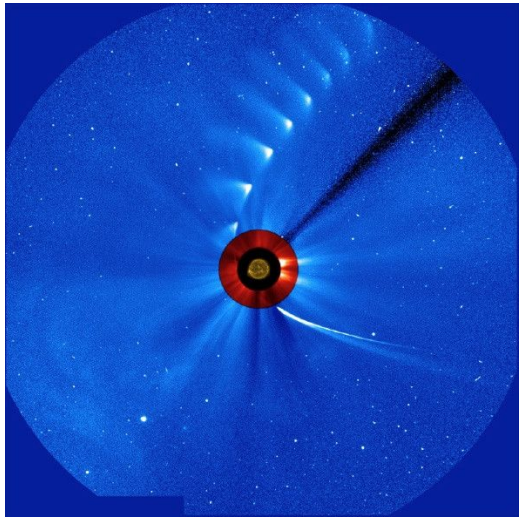
Ceres: 1.5×10^{-4} $M_\oplus$

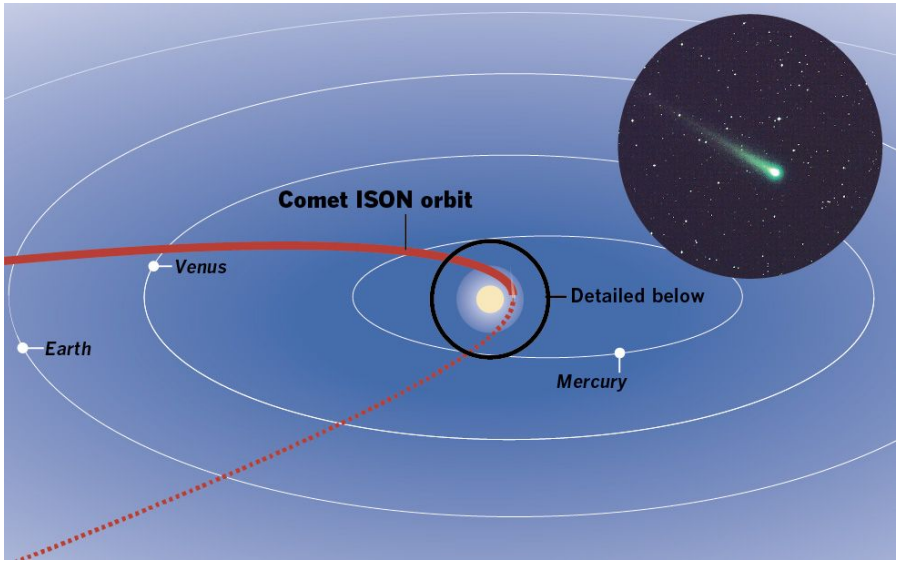
Mercury: 0.055 $M_\oplus$

(Marshall et al. 2023)

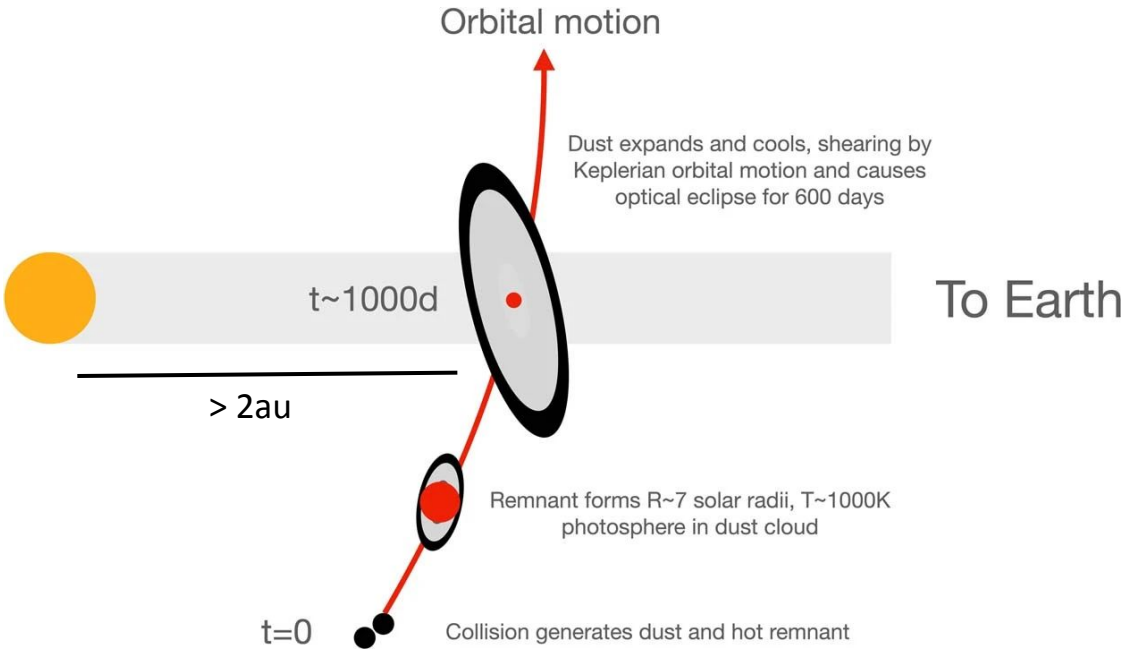
Possible scenarios – “Vulcanoids”

- Collision between two or more asteroids or comets
- Disintegration of a large stargrazing comet
- Impact of a high velocity comet onto a Mercury-like planet



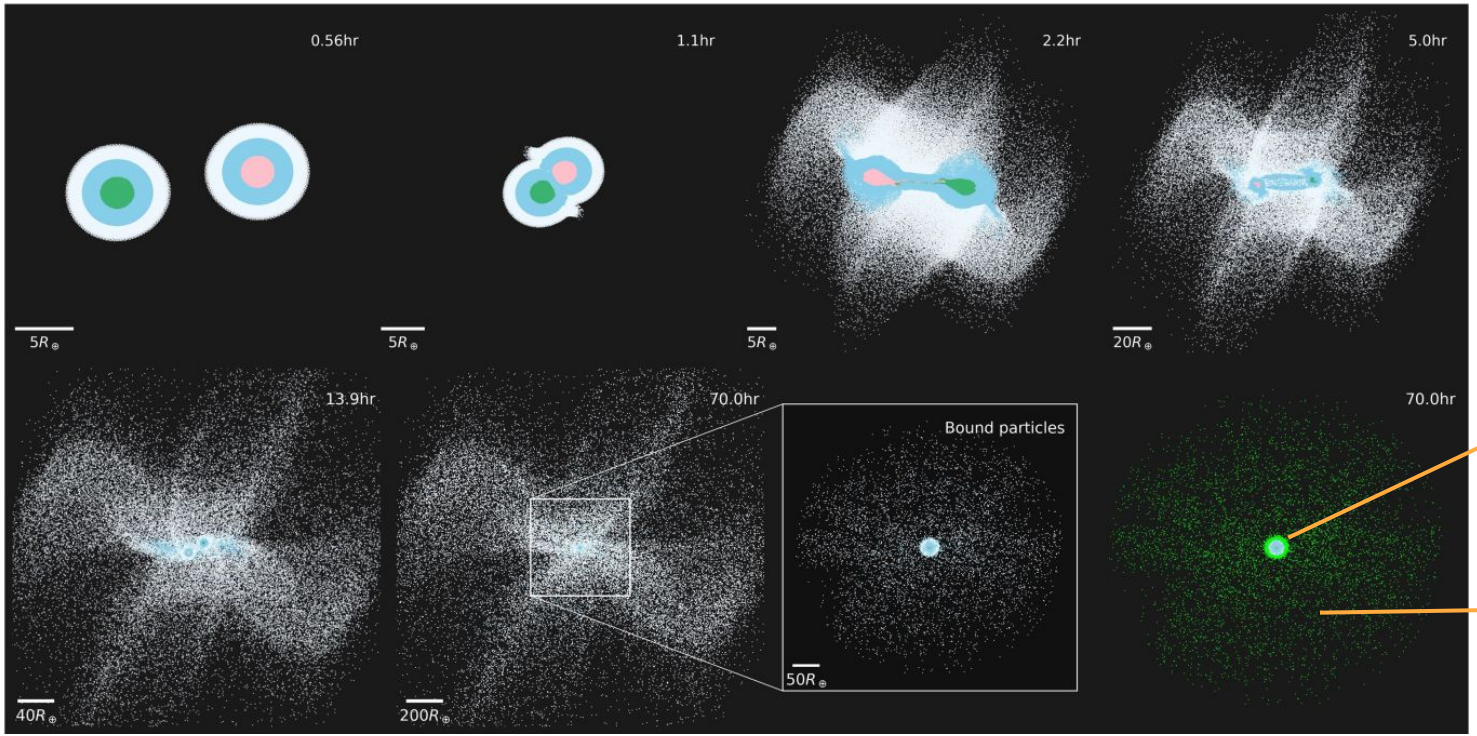


An alternative explanation



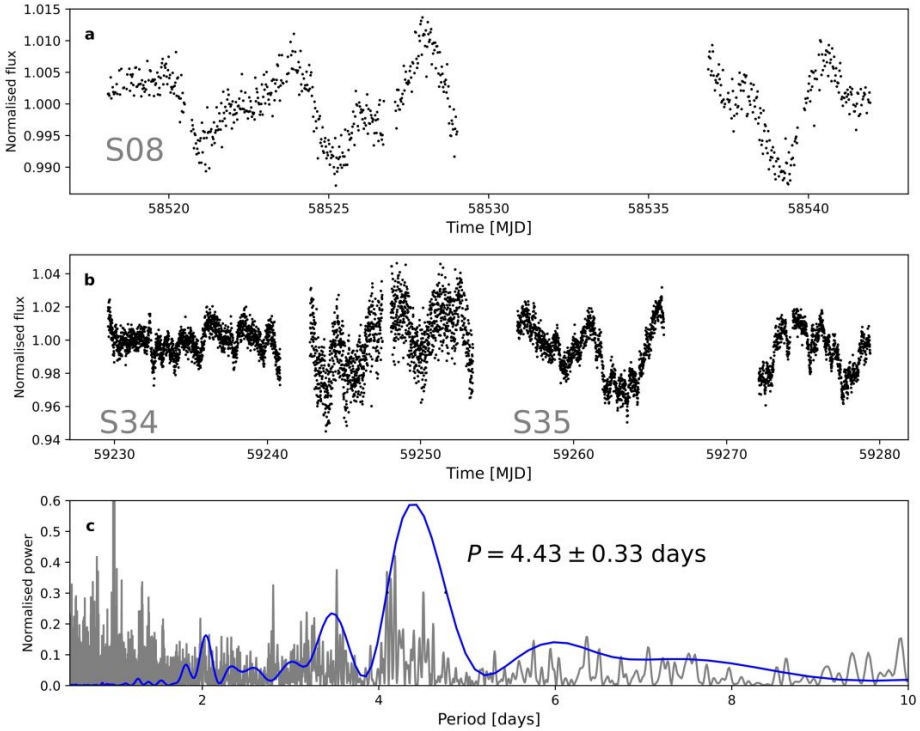
(Kenworthy et al. 2023)

Dimming and NIR emission not from same source



(Kenworthy et al. 2023)

Stellar age: 300 Myr



(Kenworthy et al. 2023)

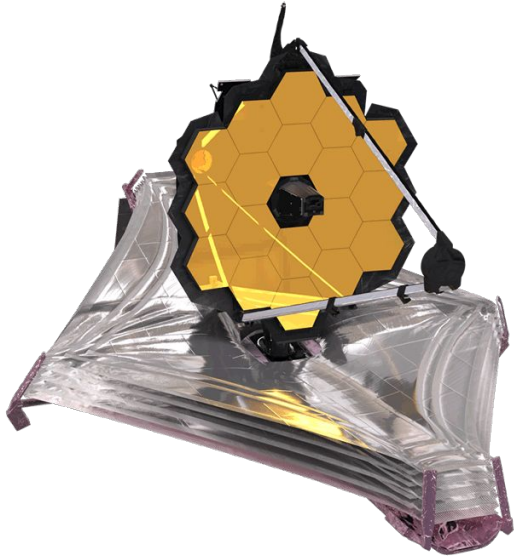
Follow-up observations to distinguish between scenarios

Optical spectroscopy: Determination of the stellar age

Infrared spectroscopy: Thermal emission from NIR emitter

spectral features point to small dust grains ⟶ debris cloud

smooth spectrum ⟶ post-impact body



Probabilities

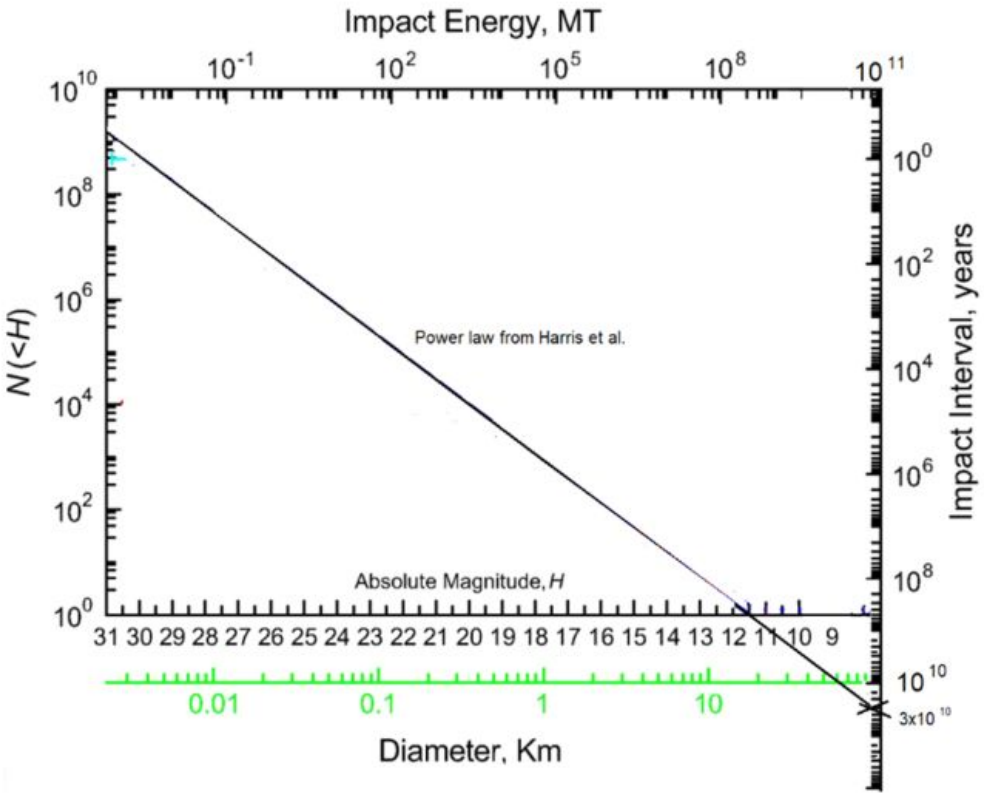
Extinction level impact events happen during the main sequence

Search for NIR brightening

NEOWISE

Search for dimming

ASASSN / Rubin / GAIA

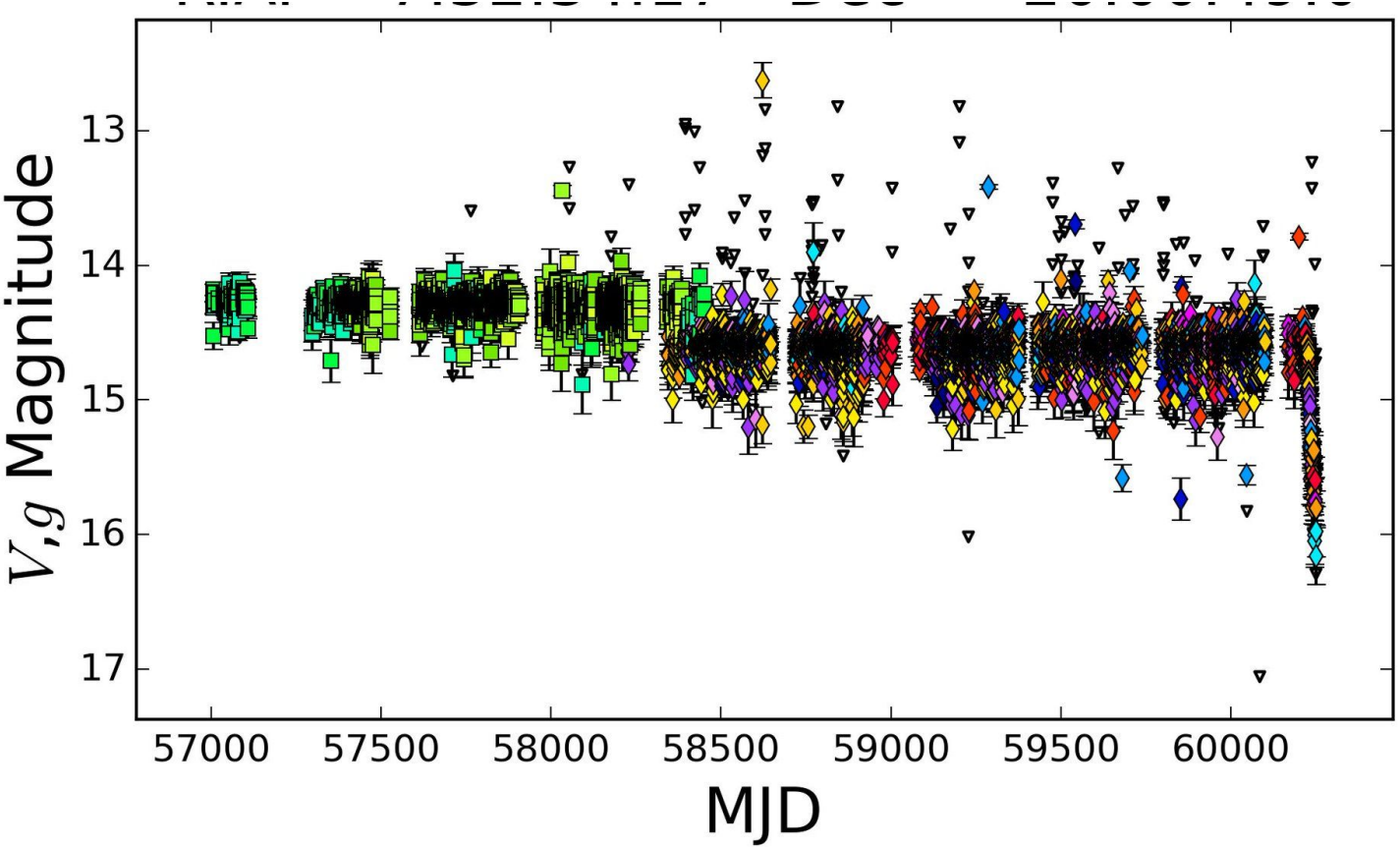


(Salotti 2022)

Conclusions

- KIC 8462852 and ASASSN-21qj are both extreme dimming events
  - KIC 8462852 has little room for warm dust $\rightarrow$ no planetary collision
  - NIR brightening in ASASSN-21qj implies the presence of warm dust (or a thermally emitting object)
- ASASSN-21qj
  - catastrophic break-up of a comet, a collision between asteroids or the impact of a comet on a Mercury-like planet (more likely; Marshall et al. 2023)
  - colliding ice giants (less likely; Kenworthy et al. 2023)
  - future observations will distinguish between scenarios
- Events involving minor objects are relatively common (once in 10^8 years)
  - Rubin (LSST) / GAIA / NEOWISE
- Impact modelling and probability evaluation
- Understanding the evolution of planetary systems


13
14
15
16
17
V,g Magnitude
57000
57500
58000
58500
59000
59500
60000
MJD
BREAKING
NEWS


13
14
15
16
17
V,g Magnitude
57000
57500
58000
58500
59000
59500
60000
MJD