Evidence for Shock Darkening/Impact Melt on Near-Earth Asteroid (52768) 1998 OR2

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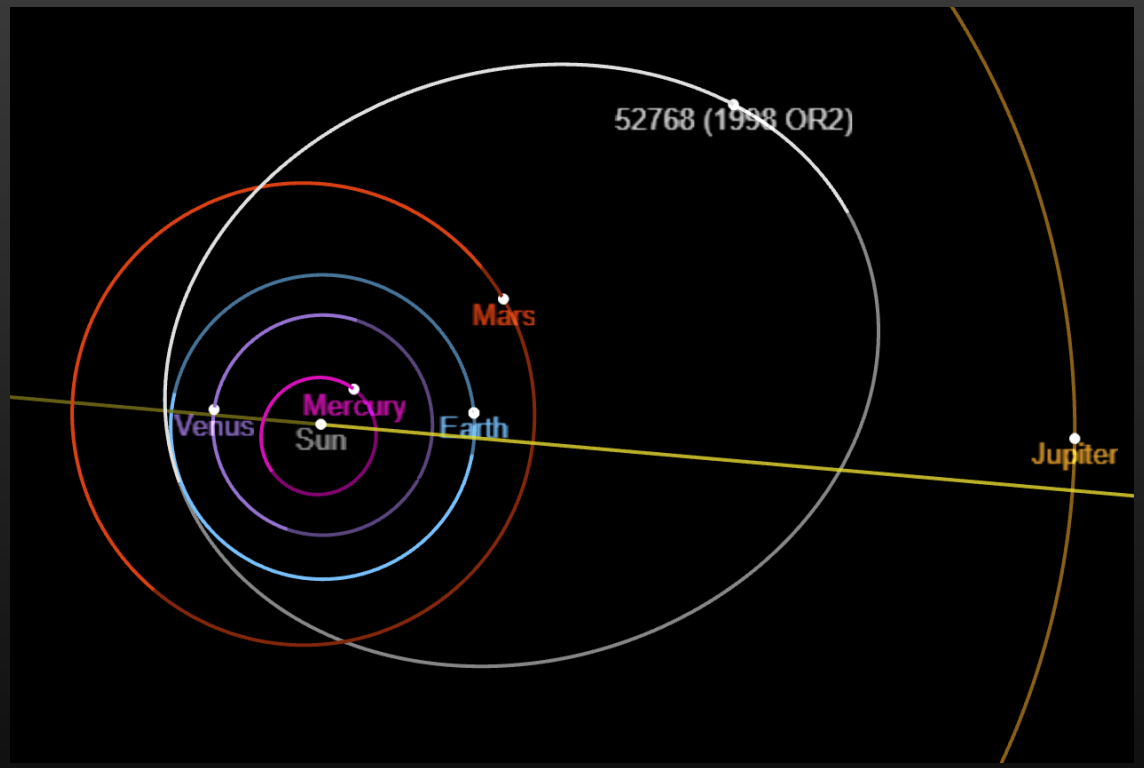
(52768) 1998 OR2



JPL Solar System Dynamics

- Potentially hazardous, near Earth asteroid (NEA)
- Diameter of ~2.2 km (~1.5 miles)
- Rotation period = 4.1 hrs
- Observed during close approach to Earth in April 2020 (~16 LD)
- Goal is to constrain the rotation period and composition of 1998 OR2

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Observations

- Visible spectroscopy observed with RAPTORS I on the campus of the University of Arizona (top)
- Archived MITHNEOS survey NIR spectra taken with NASA's Infrared Telescope Facility (IRTF, bottom)
- Photometry observed with Leo Observatory, 0.5-meter
- Additional information available from Arecibo and NEOWISE

RAPTORS I
Credit: Vishnu Reddy

NASA IRTF
Credit: Ernie Mastroianni

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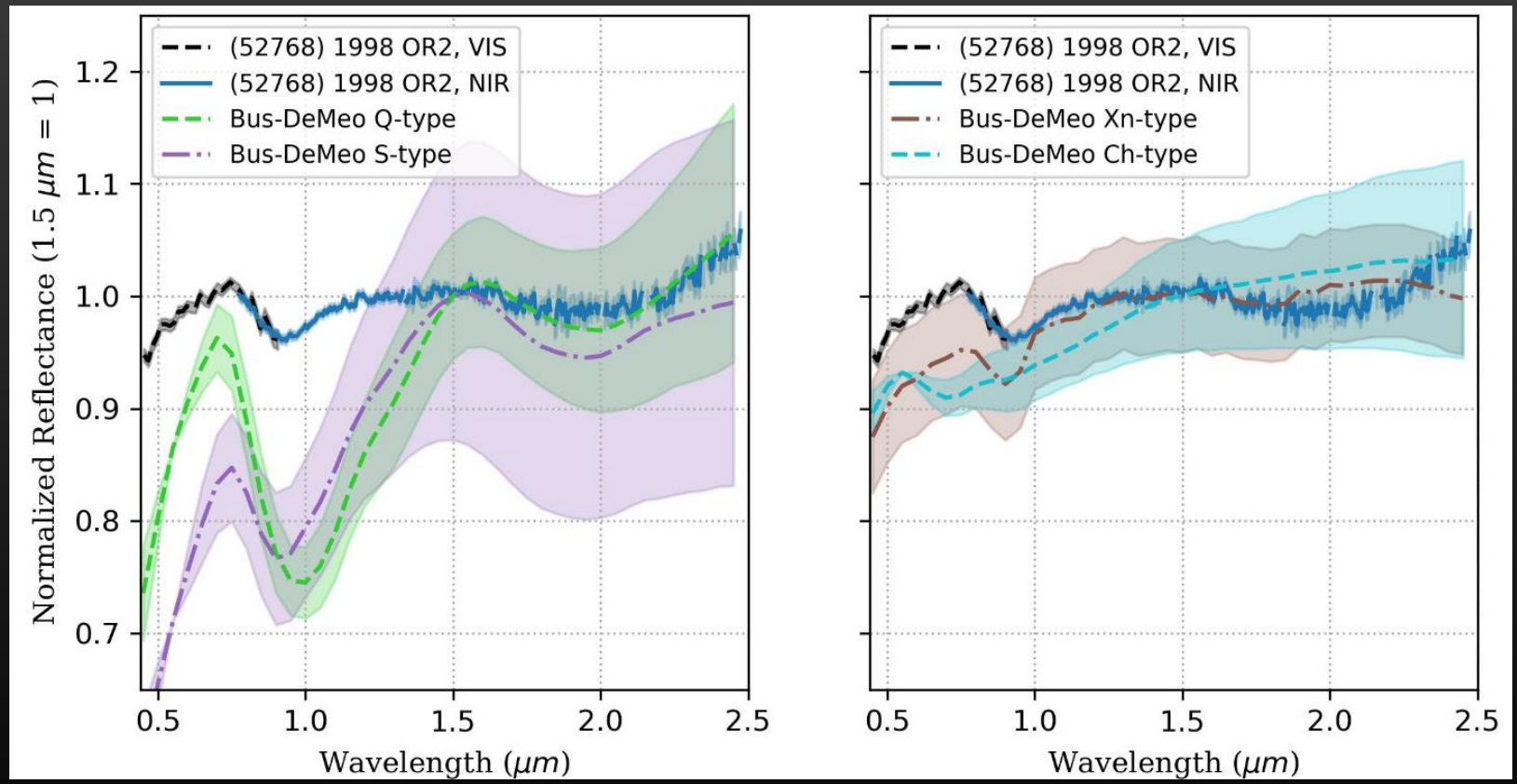
Visible and Near-IR Reflectance Spectra

- Comparisons with Bus-DeMeo taxonomy types (DeMeo et al. 2009)
- S- and Q-types:
  - Look similar, but scale is different
  - Mineralogy matches
- Ch-type:
  - Closest chi-squared match
- Xn-type:
  - Overall best taxonomic match



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Other Spectral Alteration Sources

- Many factors affect an asteroid's spectrum that we could rule out:
  - Space weathering
  - Grain size
  - Metal content
  - Viewing geometries
- Only shock darkening/impact melt (SD/IM) remained as a strong candidate
- Meteorite analog study supports 1998 OR2 being dominated by shock darkened material

Chergach

Shock darkened H chondrite

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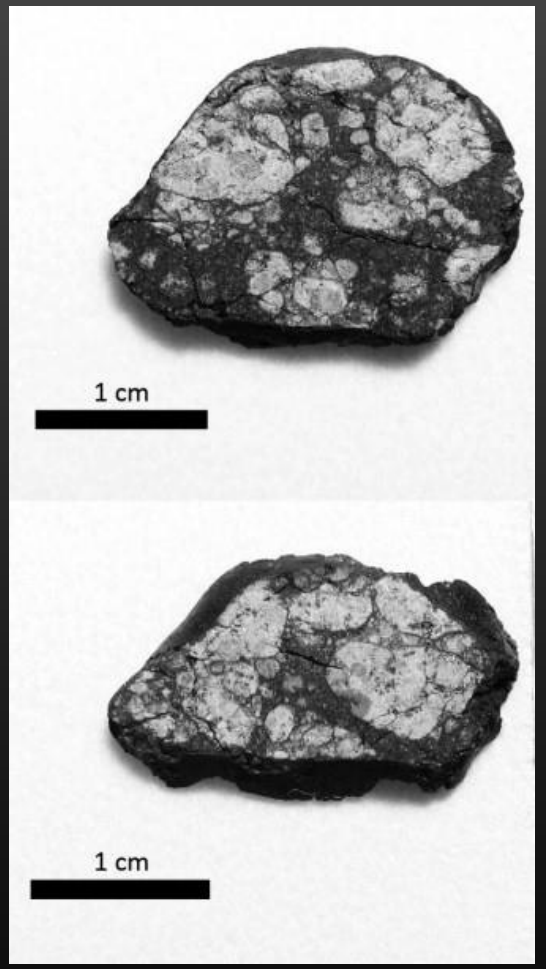
Shock Darkening/Impact Melt (SD/IM)

- Occurs when something impacts a planetary body, melting some of the rock
- Alters the body's appearance both to the eye and in spectra of the object
- The difference between SD/IM is the degree of melting
- Composition is unaffected

- Shock darkening causes incorrect classification and misunderstanding of asteroid properties



Chelyabinsk

Shock darkened LL chondrite

From Reddy et al. (2014)

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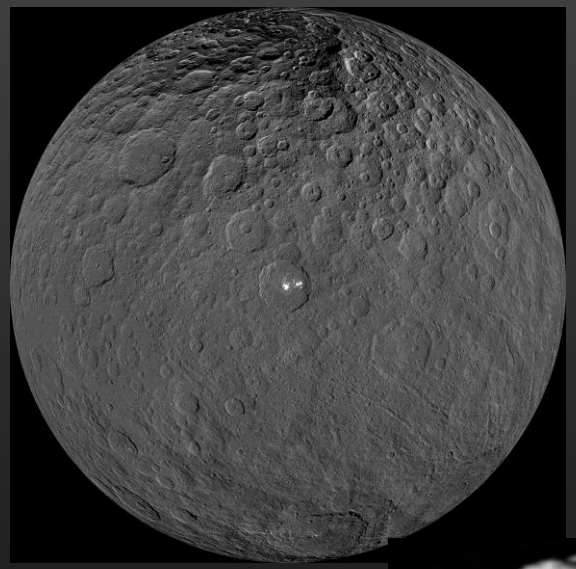
Impacts in the Solar System

- Impacts are common in the solar system
- Seeing SD/IM is *not* common
- Asteroid taxonomy relates to physical properties
  - C-types are lower density and more fragile
  - S-types are higher density and stronger



NASA Dawn image of Ceres

ESA Rosetta image of Šteins

NASA NEAR image of Eros

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Summary

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- The visible and NIR spectrum of 1998 OR2 best matches ordinary chondrites, but looks carbonaceous
  - Shock darkening is most likely cause of alteration
  - Meteorite analog analysis supports this
- This is the first evidence of shock darkening dominating the surface of a near-Earth asteroid

Takeaways:

- Shock darkening causes us to incorrectly classify asteroids
- Ordinary chondrite material could be “hiding” on asteroids misclassified as C/X-type
- This affects our understanding of asteroid physical properties

Paper available on PSJ: https://iopscience.iop.org/article/10.3847/PSJ/ac7223

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Images:

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- https://nssdc.gsfc.nasa.gov/planetary/mission/near/near_eros_2.html
- https://solarsystem.nasa.gov/resources/617/high-resolution-ceres-view/
- https://sci.esa.int/web/rosetta/-/43356-2867-steins

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