Surveying the Asteroids & Comets with NEOWISE

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Why Study Asteroids with Infrared?

• Infrared $\rightarrow$ diameter errors ±10%
  – Visible light $\rightarrow$ diameter errors ±200-300%
  – $\rightarrow$ impact energy errors of 10-30x

• Representative sample
  – Equally sensitive to dark asteroids missed by visible light surveys
  – Space-based survey has consistent biases that are easier to model accurately: no weather, no seeing, no daytime

• Unbiased sample: IR $\sim$ insensitive to albedo ($p_V$)
Wide-field Infrared Survey Explorer (WISE)

- Astrophysics Medium Explorer mission surveyed the entire sky at 3.4, 4.6, 12, 22 \( \mu m \)
- 40 cm telescope using solid hydrogen cryostat
- Sun-synchronous 525 km orbit
- PI: Ned Wright, UCLA
- Prime mission: 14 Jan 2010 – 1 Feb 2011
- NEOWISE:
  - Funded by NASA Planetary Science
  - Created an archive of individual epoch images + a tool for accessing them
  - Permitted the discovery of new asteroids with WISE
New NEOs
Known NEOs
New Comets
Known Comets

- >158,000 total asteroids observed
- ~34,000 new discoveries
- ~700 NEOs
- 135 NEO discovered
- ~150 comets
• ~430 NEOs
• No significant change in albedo vs. diameter
  – Albedo is constant all the way down to small sizes
• Contrary to previous studies that are biased against small, low albedo objects
New Estimate of Numbers of NEAs

A Near-Earth Asteroid Census
Each image represents approximately 200 objects

Known Near-Earth Asteroid Population
New Predicted Total (NEOWISE) ○
Old Predicted Total (pre-NEOWISE) ○
Potentially Hazardous Asteroids

- 4700 ± 1500 PHAs larger than 100 m
- 2x more PHAs in low inclination orbits
  - More hazard, but more potential low $\Delta v$ targets for exploration

Reactivated WISE satellite 13 Dec 2014 using 3.4 & 4.6 um channels until late 2016
  − Renamed NEOWISE (A. Mainzer PI)

NEOWISE discoveries are large, dark; 25% potentially hazardous asteroids
  − 45 NEOs & 3 comets discovered to date
  − 1st NEO discovery 6 days after survey start

~12,000 objects observed to date, including 281 NEOs
Future Project:
Near-Earth Object Camera (NEOCam)

- NEOWISE: the prototype for a more comprehensive NEO survey
- NEOCam: A bigger, better NEOWISE
  - Larger field of view
  - Longer lifetime
  - No expendable cryogens
- Earth-Sun L1 orbit
Enhanced Visibility Zones

- NEOWISE Viewing Zone
- NEOCam Viewing Zones
- Mars
- 30 m NEO detection limit
- Earth
- NEOCam is at L1
- 140 m NEO detection limit
- 500 m NEO detection limit
NEOCam Detectors

- Have made $1024^2$ HgCdTe arrays that operate from 0.4 – 10.7 um (McMurtry et al. 2013, Girard et al. 2014)

- Excellent quantum efficiency, dark current, read noise, well depth: exceeds NEOCam requirements at 35-40 K
NEOCam Integral Survey
Completeness for NEAs >140m

• 2/3 of potentially hazardous asteroids >140 m ~3 years
• 10% of 50 m NEAs
• Superior performance to Venus-trailing orbit, even assuming no lossy compression
Conclusion

- Space-based infrared surveys are an efficient means of finding asteroids, characterizing them, and learning about our solar system