Characterizing Small Recently Discovered NEOs: Diameter and Albedo Measurements

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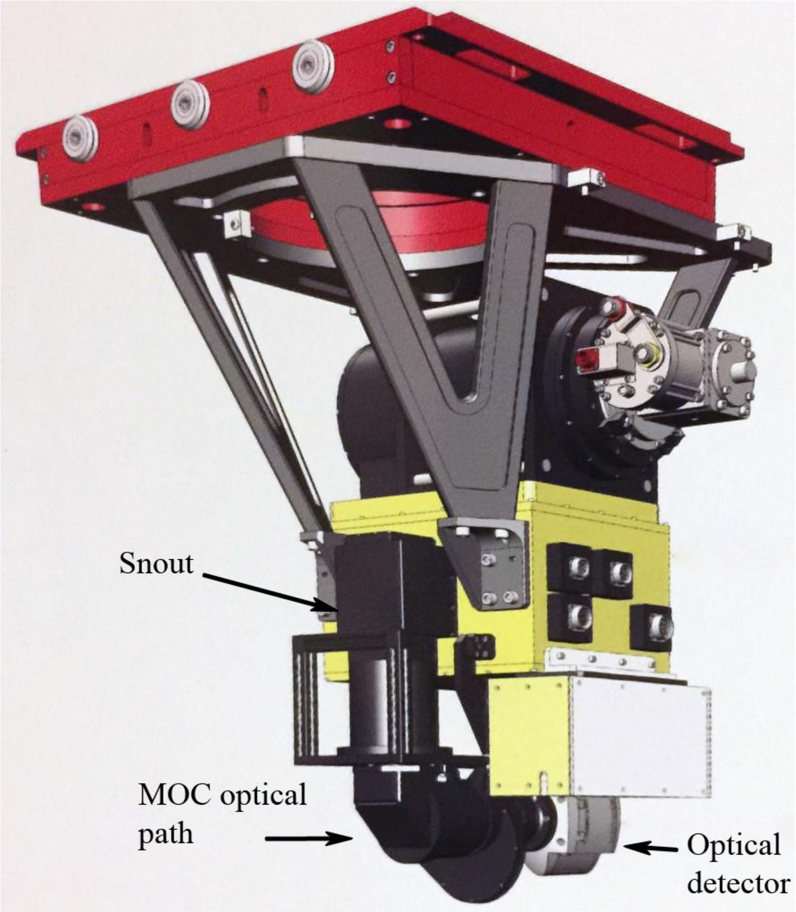
NEOs from the NASA-IRTF: MIRSI+MOC

- MIRSI is a thermal IR spectrograph and imager camera at the NASA-IRTF
- The new design include an optical camera, MOC
- Easily accessible and operable system for NEOs characterization and planetary defense support
- Optical+Thermal = accurate albedo and diameter



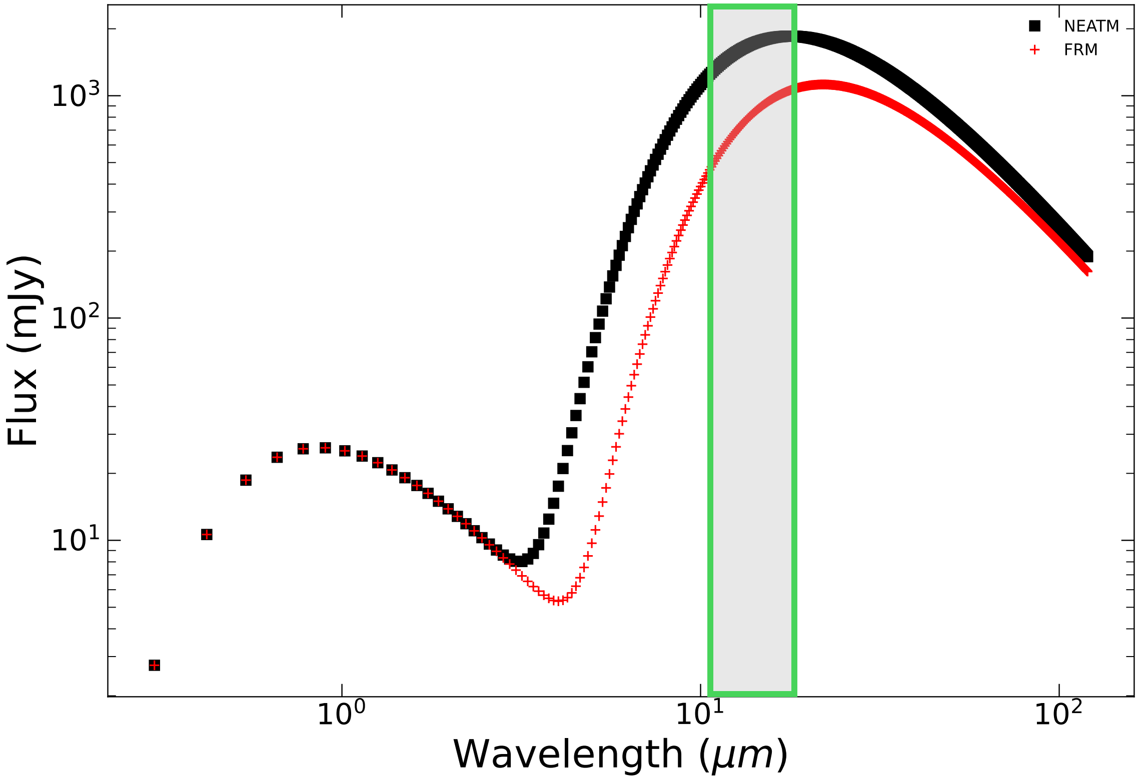
Hora et al. 2024

Spectral Energy Distribution of NEOs

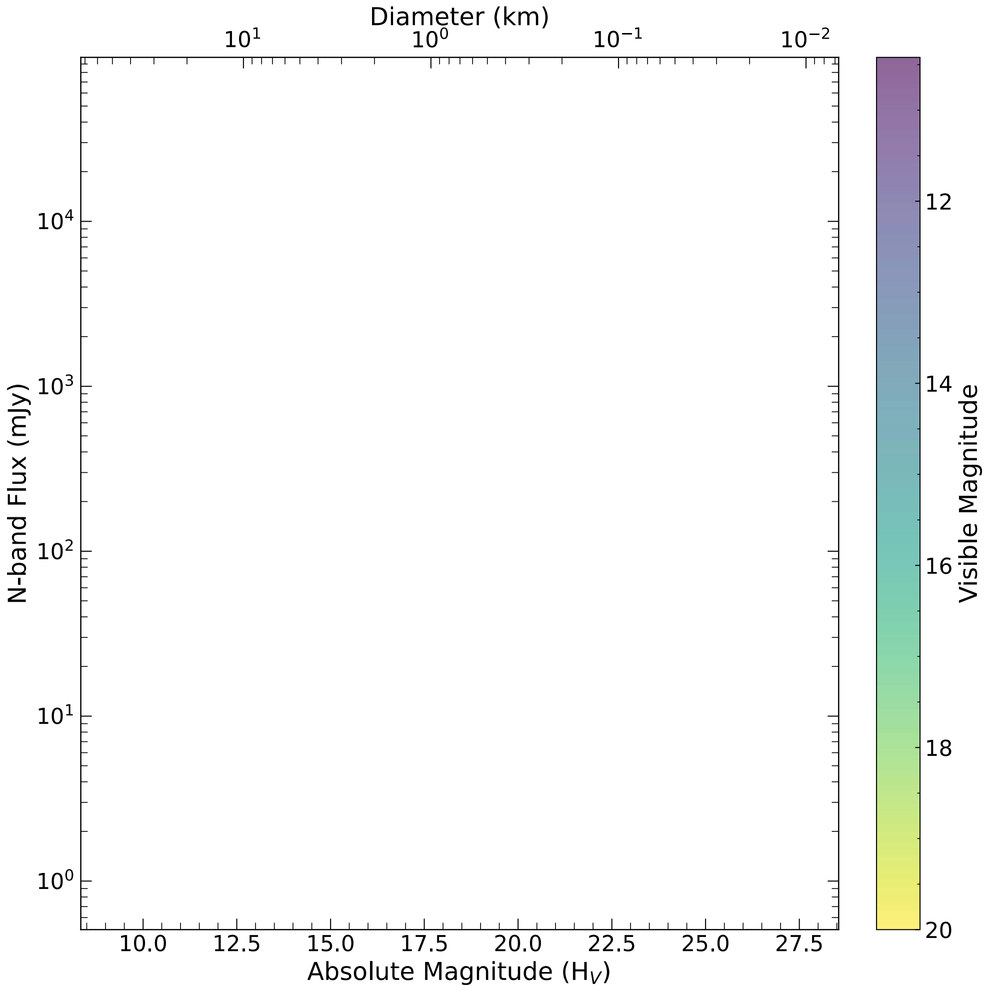
- Standard Thermal Model
- Near-Earth Asteroid Thermal Model
- Fast Rotator Thermal Model
  - Isothermal Latitude Model

$$D = \frac{1329}{\sqrt{p_V}} 10^{-\frac{H_V}{5}}$$

MOC

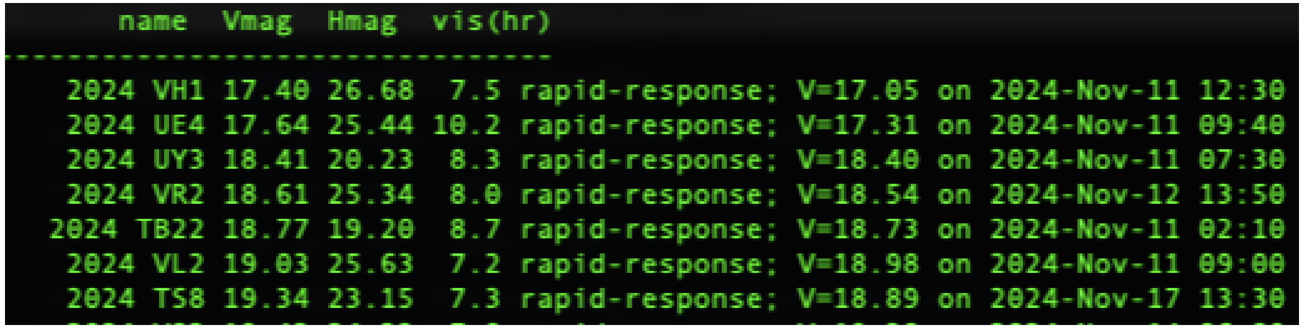


Predicted SED of Observable NEOs



MIRSI as a Support for Planetary Defense

- The MIRSI-NEO program, typically consist of characterizing ~30 known NEOs/year
  - 3-4 hours observing blocks
- If available, we prioritize recently discovered NEOs



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     name   Vmag   Hmag   vis(hr)
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   2024 VH1 17.40 26.68  7.5 rapid-response; V=17.05 on 2024-Nov-11 12:30
   2024 UE4 17.64 25.44 10.2 rapid-response; V=17.31 on 2024-Nov-11 09:40
   2024 UY3 18.41 20.23  8.3 rapid-response; V=18.40 on 2024-Nov-11 07:30
   2024 VR2 18.61 25.34  8.0 rapid-response; V=18.54 on 2024-Nov-12 13:50
  2024 TB22 18.77 19.20  8.7 rapid-response; V=18.73 on 2024-Nov-11 02:10
   2024 VL2 19.03 25.63  7.2 rapid-response; V=18.98 on 2024-Nov-11 09:00
   2024 TS8 19.34 23.15  7.3 rapid-response; V=18.89 on 2024-Nov-17 13:30
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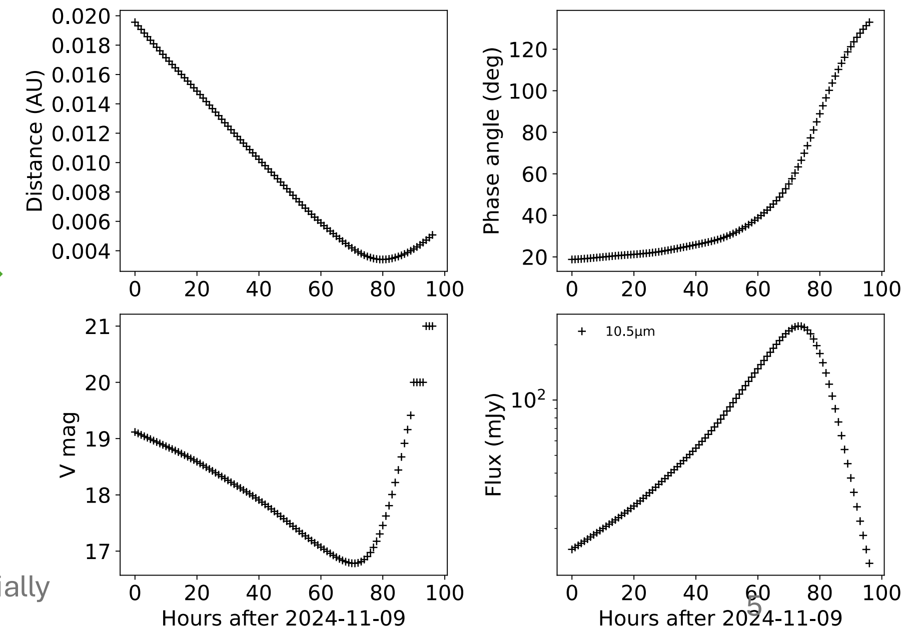


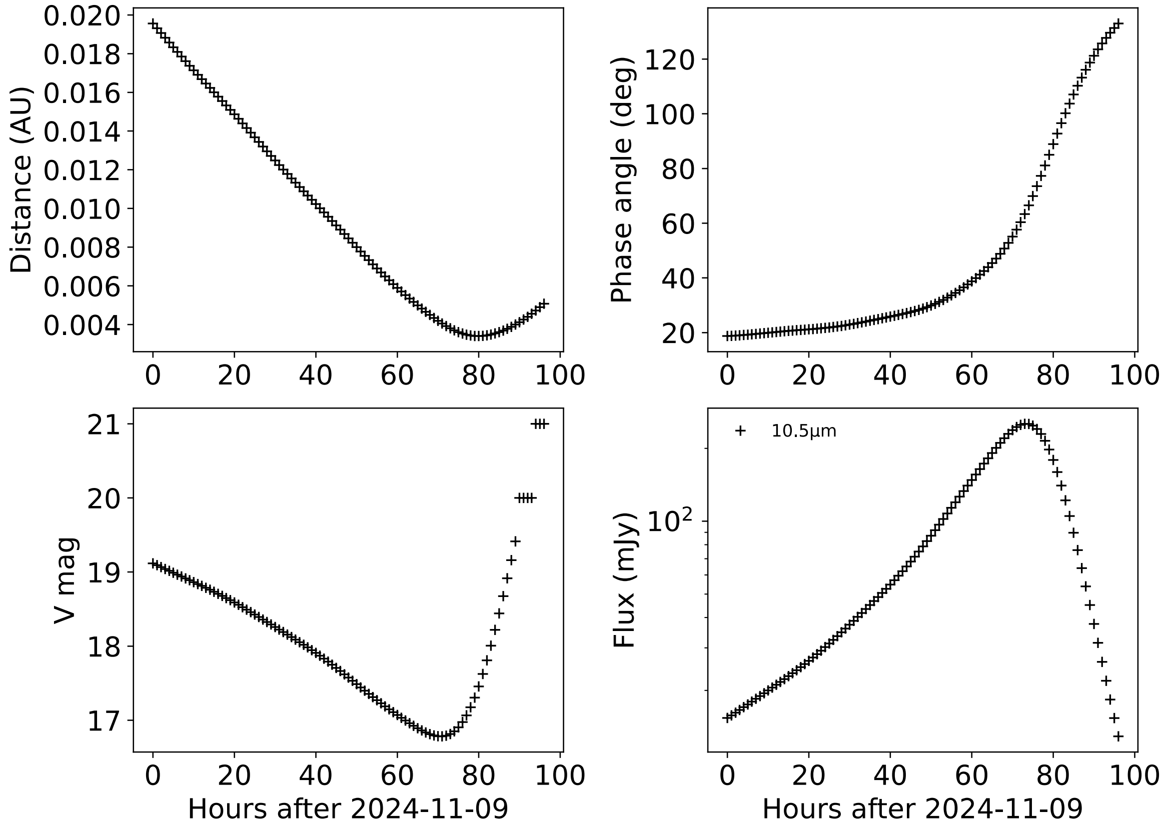
MIRSI as a Support for Planetary Defense

- The MIRSI-NEO program, typically consist of characterizing ~30 known NEOs/year
  - 3-4 hours observing blocks
- If available, we prioritize recently discovered NEOs
  - Must fall within our requested block
  - Must be bright enough for MIRSI (>120 mJy)
- So far, we have characterized 6 recently discovered NEOs
  - Simultaneous R-band photometry $\rightarrow H_V \rightarrow p_V$
    - Color measurements are also possible to determine taxonomy with MOC

Recently Discovered Asteroids

- Represents the smaller members of the NEOs population (D<100m)
- Short observing window
- Fade in brightness quickly after close approach
- Requires a fast response observing technique
  - Queue formatted telescopes (ideal)
  - Director's Discretionary Time (ToO-IRTF)

2024 VH1



MIRSI as a Support for Planetary Defense

- Diameter and albedo provide information on two critical aspects of planetary defense
  - Size
  - Composition
- International Asteroid Warning Network (IAWN; Reddy et al., 2024)
  - A global planetary defense practice
  - During the 2023 DZ2 campaign, MIRSI contributed by measuring the albedo and diameter range in a 35 minutes block
    - $19\,m > \ D_{eff} < 26\,m$
    - $p_V \sim 49\%$
    - ~6 minutes rotation period (MOC)

Advantages of MIRSI for a Fast Characterization

- MIRSI is always at operational conditions (T~5K)
- MOC provides simultaneous optical characterization
  - Minimization of H uncertainties at the time of the observation
    - Account for irregularly shaped objects with high amplitude
- Data acquisition, reduction, and analysis in (almost) real-time

Disadvantages of MIRSI for a Fast Characterization

- The target must be bright enough to be detected by MIRSI with its current sensitivity (>~120 mJy)
- MOC is a guiding camera with FOV ~1’x1’
  - Uncertainty in the NEO ephemeris could difficult it’s identification
  - Inaccurate position of the NEO in the MIRSI FOV would make challenging the blind stacking process
  - Include Opihi to recover the NEO (i.e., 2024 JT3 found 110+ arcseconds away from nominal)
- The observability window of recently discovered NEO is quite narrow upon close approach…

Lessons Learned & Takeaways

- Optimizing Interrupt Time Allocation at NASA-IRTF
  - High-demand facilities should incorporate better coordination and “last-minute” communication between scheduled observers
  - Clearly stating in the observing proposal whether the program could be relocated if high-priority circumstances require so
    - Observers are under no obligation to provide access
- MIRSI is a “ready-to-go” optical and mid-IR camera to measure albedos and diameters of newly discovered asteroids accurately
  - We have tested the MIRSI+MOC system under the scenario of a possible impact to improve our planetary defense strategies
- Github repository for reduction pipeline: https://github.com/jhora99/MIRSI