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Serendipitous Asteroid Detections with JWST-MIRI

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Abstract

The James Webb Space Telescope is scheduled to be launched in early 2021. With a primary aperture of 6.5m and its mid-IR instrument MIRI observing between $\sim$ 5µm and $\sim$ 28µm, it will be an excellent tool for thermal studies of asteroids. We propose to exploit serendipitous asteroid detections, obtained using the MIRI imager while the medium-resolution spectrometer (MRS) is prime.

We estimate the number of asteroids detected by MIRI over its five-year lifetime requirement. These will be predominantly sub-km main-belt asteroids (MBAs), a population that is poorly characterized by current surveys due to their faintness. MIRI will obtain high-quality photometry (SNR $\gg 10$) of $> 5,000$ sub-km MBAs, allowing their diameter and, in the presence of optical photometry (H magnitude), their geometric albedo p_V to be measured.

1. Simultaneous Imager MRS Observations

Besides targeted asteroid observations, many asteroids will be detected serendipitously during MIRI observations. Importantly, the MIRI imager can be (and by default: will be) set to take data while MIRI's Mid-Resolution Spectrometer MRS observes a nearby field. These Simultaneous Imager MRS Observations (SIMO) come at no time charge to the MRS observer, neither is the created data volume critical. *There is no good reason for MRS observers to deactivate imager observations!*

The apparent motion of main-belt asteroids is well matched to MIRI's spatial resolution, so MBAs will be easy to identify and characterize. Near-Earth asteroids, however, will typically move too fast, while trans-Neptunian Objects would require longer wavelengths.

Comparing the typical spectral energy distribution of the thermal emission of an MBA to MIRI's imaging sensitivities, we identify the F1280W filter (centered at a wavelength of 12.8 µm) as the optimal filter, providing the highest SNR per time on MBAs.

To mitigate against the possible effects of saturation and trailing (these are sidereally tracked observations), we recommend users set the imager to use 11 FAST readouts per exposure (see Fig. 1).

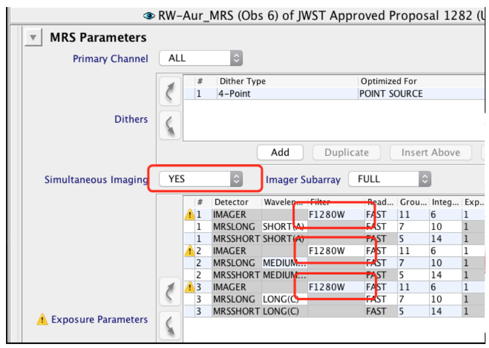

Figure 1: Screenshot taken from the Astronomer's Proposal Tool APT to be used for JWST proposals. Highlighted are the recommended imager settings to optimize the yield in serendipitously detected asteroids during MRS observations. *Please always use these settings* (and encourage your non-planetary colleagues to use them) unless you have overriding science reasons!

2. Estimated Asteroid Yield

We are studying the number of MBAs detected by MIRI within its required five-year lifetime. We base ourselves on an approved MIRI GTO program. For each MIRI-imager pointing contained in the program (both dedicated imager observations and imager simultaneously with MRS), we determine a time at which the observation could be executed given observatory constraints. We then query NASA JPL's ISPY tool for known asteroids within our FOV at that time, then estimate their mid-IR flux and derive expected SNR values. We find practically all asteroids within MIRI's FOV to be detected at SNR $\gg 10$, allowing diameters to be measured. MIRI is far more sensitive to asteroids than current optical survey facilities!

In doing so, we estimate the number of *currently known* MBAs to be in the hundreds. Upcoming more sensitive surveys, chiefly LSST, should provide many more asteroid discoveries in time to be characterized by MIRI. Assuming an exponential size-frequency distribution as is commonly done, we arrive at an estimated total yield of $\gg 5,000$ asteroids that will be measured at SNR ≥ 10, dominated by sub-km MBAs.

3. Summary and Conclusions

Serendipitous MIRI detections will provide the first large catalog of diameters and albedos for sub-km MBAs, much surpassing the sensitivity of current surveys.