NEOWISE Techniques for Cometary Coma Extraction and Nucleus Size Determination in the Infrared

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THE INFRARED WAVELENGTH ADVANTAGE

The coma of comets is often difficult to model. The coma fitting routine developed by Lisse et al. (1999) and applied by Fernandez et al. (2013) was adapted and applied to the NEOWISE sample in Bauer et al. 2017. The wings of the coma were fit along summed 3° wedges of azimuth around the location of peak brightness with a(1/r) profile, where $0.65 < n < 1.85$, in combination with a point-spread function (PSF) at the center. This technique produced a successful extraction for most of the prime mission sample of comets, but failed for images where the coma

1. was highly anisotropic, with jets or other features that were not along a constant azimuth, and
2. dominated the nucleus signal, i.e. the nucleus signal was low-contrast relative to the coma.

Such circumstances were well-described and characterized in Hui et al. (2018), who applied the technique to simulated data of coma and nucleus at visual-band wavelengths. These typically produce an under- or over-subtraction bias in the coma-subtracted image (see Figure 2 in Bauer et al. 2017). However, comet images in the infrared generally have 2 advantages:

First, the sub-micron dust signal contribution, a size regime that is more readily effected by radiation pressure effects, is diminished.

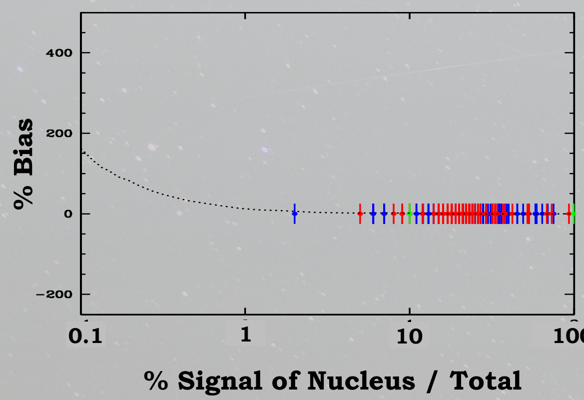

Figure 1: *A comparison of coma-extracted diameters with potential bias as a function of nucleus signal. The theoretical work by Hui & Li (2019), shown here (dotted line) for a NEOWISE-like over-sampling rate of 3, demonstrates that the NEOWISE cryo-mission LPC (blue) and JFC (red) nucleus/total signal ratios are optimum for the application of the nucleus/coma extraction. This also applies for the extraction of the diameters for the NEOWISE reactivated mission bands (green).*

Second, especially at thermal wavelengths, the nucleus signal is stronger relative to the dust, i.e. the contrast is greater, within a few PSF of the central-condensation.

Hence, generally, the technique is more successful in the infrared, can be applied to data from all phases of the NEOWISE mission (Mainzer et al. 2014) and will work for NEO Surveyor as well.

THE SIZES OF C/2020 F3 NEOWISE & 96P/MACHHOLZ

The coma fit and extraction in the two shorter-wavelength bands is potentially more complex, owing in part to the presence of gas emission signal in the 4.6 micron band. However, an updated version of the technique was recently successfully employed to obtain estimates of the nucleus size of C/2020 F3 (NEOWISE). The photometry applied to the coma-subtracted image, yielded fluxes consistent with a nucleus of diameter ~5 km.

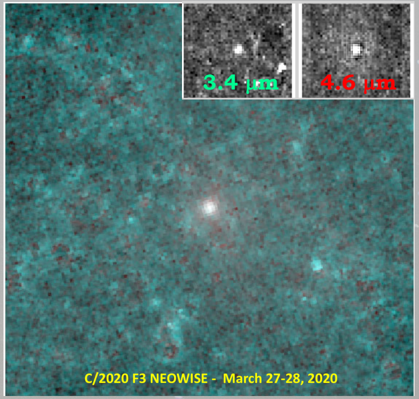

Figure 2: *A stack of 13 NEOWISE exposures taken March 27 and 28, 2020 centered on the Great Comet of 2020, C/2020 F3 (NEOWISE), 6 arcmin on a side and oriented with North up and East to the left. In this 3-color image, the 3.4 μm channel is mapped to the blue and green channels, while the NEOWISE 4.6 μm channel is mapped to red. The stack was taken when the comet was at a distance of 2.1 AU from the Sun and 1.7 AU from the Earth. The insets show the extracted nucleus in each band.*

For comparison, comet 96P/Machholz 1 was observed on August 14, 2018. No evidence of coma was apparent, even in the surface-brightness profiles below. Using the same thermal model as Bauer et al. (2017), we derived a size of 6.45 +/- 0.41 km, yielding a visual-band albedo of ~4%.

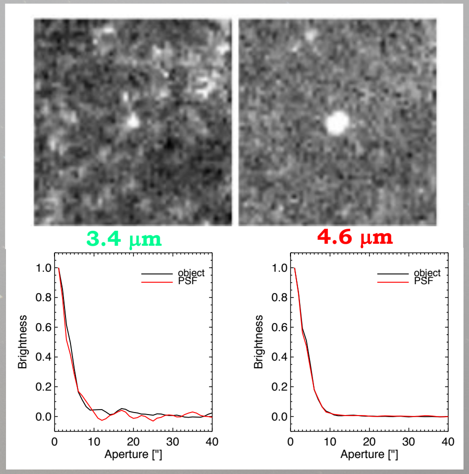

Figure 3: *A stack of 12 NEOWISE exposures pf 96P, 6 arcmin on a side and oriented with North up and East to the left. Below are the surface brightness profiles for each band, showing no evidence of coma.*

REFERENCES

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NEOWISE Explanatory Supplement

NEO Surveyor Mission