Asteroid 306128 Pipher

There are many interesting minor bodies in our solar system, but our favorite hereabouts is 306128 Pipher. This main-belt asteroid was discovered 12 May 2010 by the Widefield Infrared Survey Explorer (WISE). Originally it was labelled with a serial number, 2010 JP109, by the data-reduction pipeline. NEOWISE principal investigator Amy Mainzer, noting that the serial number contained Judy Pipher's initials, decided that The Stars were sending her a message. Amy proceeded to conspire successfully with Eric Mamajek to get the asteroid officially named after Judy by the IAU Commission on Naming of Astronomical Objects. The citation, issued on 31 January 2018 [1] by the Minor Planet Center:

> Judith Pipher (b. 1940) is an astrophysicist and Emeritus Professor at the University of Rochester. One of the first U.S. astronomers to observe the skies with an infrared array camera, she is known as "the mother of infrared astronomy." She helped build and test infrared detectors for the Spitzer Space Telescope.

As of this writing, there exist no visible-light images of 306128 Pipher. It would be nice to get one this year, maybe even on the tenth anniversary of its discovery.

At visible wavelengths, asteroids shine in reflected sunlight, while at mid infrared wavelengths (e.g. WISE) they shine in thermal emission. Combining measurements in the two ranges, one can derive the size of the asteroid and albedo of its surface; the more photometric points gathered in these ranges, the more one can infer about the surface composition. A time series of photometric measurements will sometimes show variability from rotation – or, more often, chaotic tumbling – of the asteroid.

Most main-belt asteroids have small albedo at visible wavelengths, making it likely that 306128 Pipher is pretty faint. Observations should be attempted as close as possible to the date of Earth's closest approach to the asteroid, which in 2020 is 28 May.

In this project, you will detect 306128 Pipher, and measure its color and albedo:

- look up the asteroid's ephemeris and vital statistics, on the HORIZONS system of JPL's Solar System Dynamics group at https://ssd.jpl.nasa.gov.
- determine when the asteroid is as high as it gets in the sky as a function of date, and what its estimated visual magnitude is as a function of date. (Its visual magnitude will be reported as an upper limit, under pessimistic assumptions about the albedo.)
- estimate from these data how long a frame time can be before the asteroid's motion would broaden the pointlike image. Also estimate the total integration time necessary to get good images at L, G, and R, assuming the magnitude, G = 20, that results from taking the albedo to be the WISE estimate of 0.032. Might as well forget B, though there's no harm in trying.
- from these estimates, develop a (seeing-dependent) compromise for frame time. Plan a long sequence of autoguided observations with this frame time, or excruciating care in setting custom telescope motion rates to follow the asteroid. It's too faint for self-autoguiding.

Since 306128 Pipher is so far south these days, it does not rise above the telescope's nominal elevation limit. Special procedures and precautions will be necessary to carry out the observations. You will be required to conduct the observations in person, and to have Dan along. Maybe Judy will go too.

[1] Fields-Medal-winning mathematician Maryam Mirzakhani (Stanford) and astronomer Virginia Trimble (UCI) got asteroids officially named after them on the same day as Judy: 321357 Mirzakhani and 9271 Trimble, respectively.

In your analysis, answer the following questions:

- What is the asteroid's magnitude at G? At R?
- What are its celestial coordinates, as a function of time? It is possible that your observations may improve the accuracy with which the asteroid's ephemerides are known.
- What is the asteroid's albedo at the wavelengths of G and R? Are these values consistent with the models used by NEOWISE to determine the size of the asteroid? If not, recalculate the asteroid's dimensions from the data – yours and WISE d – and repeat.
- What photometric variability is observed, that may be interpreted as tumbling or rotation?
- How does the albedo you obtain compare to that of other main-belt asteroids?
- Did you reach the photometric accuracy that you expected? If not, why not?

Include with your report your best color image of 306128 Pipher. [2] Archive this, and all your raw and reduced data, in the AST 244/444 Wiki.

Additional reading

Astronomy 111: lecture 12.

Standard asteroid thermal model: Harris 1998, Icarus 131, 291-301.

[2] A good image is likely to be chosen to appear on the University website's front page. If you didn't take B data, generate them artificially using L, G, and R. Remember, this image is partly an exercise in art, not science.

