General framework for shape reconstruction of asteroids with disk-resolved observations

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Spin and 3-D shape are basic geometrical properties of an asteroid, yet required in understanding some of its most fundamental features, from its density to its sensitiveness to YORP and Yarkovsky non-gravitational effects. Technological advancements have made it possible to obtain highly detailed images of asteroids, yet 3-D shape modeling remains a challenge. Shape inversion is an ill-posed inverse problem as systematic errors, shading effects due to non-convex features, and the limitations of the imaging systems render the direct inversion impossible. Moreover, the image coverage of one observation session is often insufficient for 3-D reconstruction, necessitating the combination of different imaging methods.

We will discuss parametric shape representation methods, applicable to all asteroid surfaces, including strongly non-convex and geometrically non-starlike shapes. Additionally, we will demonstrate the usefulness of Fourier transform in shape reconstruction, showing that the frequency domain is a natural setting for shape inversion of image data obtained from generalized projection operators, which include virtually all disk-resolved astronomical observation methods. Finally, we present several examples and applications of our method to range-Doppler radar, adaptive optics, and thermal infrared interferometry.