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Maximum compatibility estimate for asteroid models from multiple data sources

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Detailed models can be constructed of hundreds of main-belt asteroids by using multimodal data such as combined photometry, adaptive optics imaging, occultation timings, and interferometry. We have created an inversion algorithm and software package for including multiple data modalities. When using adaptive optics images, the main information from these is extracted from the limb and terminator contours that can be determined much more accurately than the image pixel brightnesses that inevitably contain large errors for most targets. We have shown that the contours yield a wealth of information independent of the scattering properties of the surface. In addition to using the above main sources, we are extending our procedure to include range-Doppler radar and thermal infrared data.

An important concept in the inversion is the optimal weighting of the various data modes. We have developed a mathematically rigorous scheme for this purpose. The resulting maximum compatibility estimate ensures that the actual information content of each source is properly taken into account, and that the resolution scale of the ensuing model can be reliably estimated.

We have applied our technique to several asteroids, and the ground truth from the Rosetta/Lutetia flyby confirmed the ability of the approach to recover shape details. We have also created a general flyby-version of the procedure to construct full models of asteroids for which probe images are only available of a part of the surface (a typical setup for many planetary missions). We have successfully combined flyby images with photometry (Steins) or photometry and adaptive optics images (Lutetia); the portion of the surface accurately determined by the flyby constrains the shape solution of the "dark side" efficiently.