Space-based infrared surveys of small bodies

M. Mommert[1]

[1]Northern Arizona University, Department of Physics and Astronomy, PO Box 6010, Flagstaff, AZ 86011, USA

Most small bodies in the Solar System are too small and too distant to be spatially resolved, precluding a direct diameter derivation. Furthermore, measurements of the optical brightness alone only allow a rough estimate of the diameter, since the surface albedo is usually unknown and can have values between about 3 % and 60 % or more. The degeneracy can be resolved by considering the thermal emission of these objects, which is less prone to albedo effects and mainly a function of the diameter. Hence, the combination of optical and thermal-infrared observational data provides a means to independently derive an object's diameter and albedo. This technique is used in asteroid thermal models or more sophisticated thermophysical models (see, e.g., [1]).

Infrared observations require cryogenic detectors and/or telescopes, depending on the actual wavelength range observed. Observations from the ground are additionally compromised by the variable transparency of Earth's atmosphere in major portions of the infrared wavelength ranges. Hence, space-based infrared telescopes, providing stable conditions and significantly better sensitivities than ground-based telescopes, are now used routinely to exploit this wavelength range.

Two observation strategies are used with space-based infrared observatories:

Space-based Infrared All-Sky Surveys. Asteroid surveys in the thermal infrared are less prone to albedo-related discovery bias compared to surveys with optical telescopes, providing a more complete picture of small body populations. The first space-based infrared survey of Solar System small bodies was performed with the *Infrared Astronomical Satellite* (*IRAS*) for 10 months in 1983. In the course of the 'IRAS Minor Planet Survey' [2], 2228 asteroids (3 new discoveries) and more than 25 comets (6 new discoveries) were observed. More recent space-based infrared all-sky asteroid surveys were performed by *Akari* (launched 2006) and the *Wide-field Infrared Survey Explorer* (*WISE*, launched 2009). The latter performed a dedicated moving object survey program, *NEOWISE* [3], which observed >500 near-Earth asteroids (>130 new discoveries), >100,000 main best asteroids, >130 comets, as well as Trojan asteroids and Centaurs.

Space-based Pointed Infrared Observations. Not all space-based infrared observatories perform survey operations. The *Infrared Space Observatory* (*ISO*), launched 1995, performed imaging, spectroscopic, and polarimetric observations of ∼40 asteroids in the near to far infrared over 2 years. Its successor, the *Spitzer Space Telescope* was launched in 2003 and is currently in its 10th cycle of observations. Spitzer has imaging and spectroscopic capabilities covering the near to far infrared which have been and still are extensively used for a wide range of Solar System small body observations. As of the depletion of Spitzer's cryogen in 2009, only imaging at 3.6 and 4.5 µm is available. During this "Warm Spitzer" era, the "*ExploreNEOs*" project performed a survey of the diameter and albedo distributions of ∼700 near-Earth asteroids [4]. At about the same time, during its ∼4 years of operation starting in 2009, the *Herschel Space Observatory* was used to observe small bodies with its imaging and spectroscopy capabilities in the far infrared and sub-millimeter wavelengths. As part of the "TNOs are Cool!" project [5], photometric and spectroscopic data have been obtained for ∼130 trans-Neptunian objects and Centaurs, in order to derive their diameters and albedos.

Future Missions. The next space-based infrared observatory will be the *James Webb Space Telescope* (*JWST*). The JWST is expected to launch in 2018, providing imaging and spectroscopy capabilities from the near to the mid infrared with unprecedented sensitivities.

In this talk I will review the basic techniques involved in infrared observations of small bodies and present big-picture highlights from these space-based missions.

References: [1] Harris, A. W. and Lagerros, J. S. V. 2002, Asteroids III, University of Arizona Press. [2] Tedesco, E. F., Noah, P. V., Noah, M., Price, S. D. 2002, AJ, 123, 1056. [3] Mainzer, A. K., Grav, T., Bauer, J. et al. 2011, AJ, 743, 156. [4] Trilling, D. E., Mueller, M., Hora, J. L. et al. 2010, AJ, 140, 770. [5] Mueller, T. G., Lellouch, E., Böhnhardt, H. et al., 2009, EMP, 105, 209.