Asteroids as FIR/Submm/MM Calibrators

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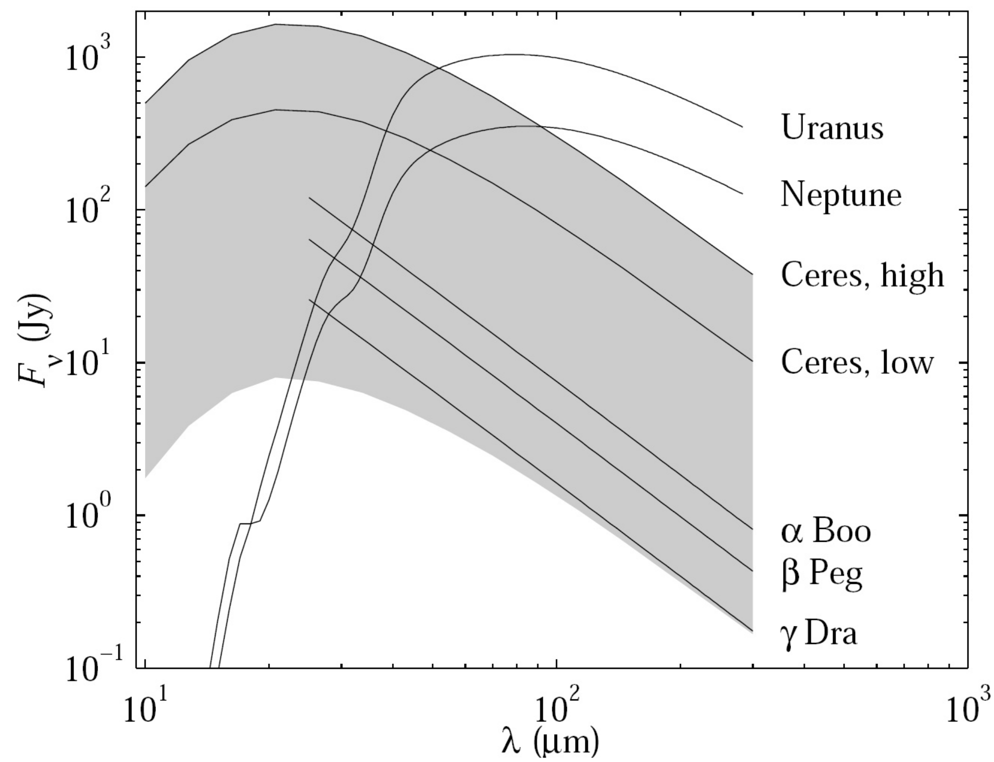
Celestial standards play a major role in astronomy. They are needed to characterise the performance of instruments and telescopes and they are an important prerequisite for accurate photometry. With the access to the far-IR, submm and mm wavelength range through satellites, airborne telescopes and sophisticated groundbased instruments, it became necessary to establish new calibrators for these wavelengths.

The traditional far-IR/submm/mm calibrators, the outer planets, are too bright or cause nonlinearity problems for modern instruments. Stellar standards are quite faint in this range and pose problems of their own. The large flux gap between these two types of calibrators could be successfully filled and complemented by a set of asteroids (see Fig. 1), which was established during the ISO mission for the ISOPHOT instrument (Müller & Lagerros, 1998, 2002, 2003; Müller et al. 2001).



But asteroids were already used during the IRAS mission (1983) to "transport" the calibration from the 60 μm band to the 100 μm band where the typical stellar calibrators were too faint (IRAS Expl. Suppl.). A similar approach was followed by the Spitzer-MIPS instrument to connect the 70 μm band to the 160 μm band where stellar sources could not be used due to a NIR-leak (Stansberry et al. 2007).

The asteroids as calibrators also play an important role for the Akari mission. The absolute flux calibration at FIR-wavelengths, but also various instrument characterisation aspects has been established via asteroid observations (Kawada et al. 2007).

In the context of the Akari and Herschel mission and in preparation for ALMA the "Asteroid Preparatory Programme" is currently conducted (Müller et al. 2005). It is a collaborative project between asteroid experts and calibration specialists from Akari, Spitzer, Herschel and many groundbased observatories.

Currently, 55 large main-belt asteroids are considered as potential calibrators spanning the flux range between about 1 and several hundred Jansky at 100 μm, at 1 mm they still reach up to a few Jansky. In the visible they produce shallow lightcurve amplitudes (indicating almost spherical shapes). They have known shape and spin vector properties and there are large sets of reliable thermal observations from mid-infrared to mm-wavelengths available.

A key element of this project is the "state-of-the-art" thermophysical modelling technique (Lagerros 1996a/b, 1997, 1998), allowing to combine the available physical target information with the existing thermal observations. The TPM technique considers the true illumination and observing geometry and takes the the one-dimensional heat conduction into the surface into account. TPM predictions (thermal lightcurves, monochromatic flux densities or full SEDs) are meanwhile accurate on the 5-20% level, depending on the object, the observing and the illumination geometry and the epoch. The full model setup includes for each asteroid:

- Shape & spin-vector information, including absolute times and phase (http://www.rni.helsinki.fi/~mjk/asteroids.html; http://astro.troja.mff.cuni.cz/~projects/asteroids3D/web.php)
- optimised radiometric solutions for the effective size and the geometric albedo (connected to the shape and spin-vector solution and based on large datasets of thermal observations)
- thermal properties (mainly the thermal inertia Γ)
- surface roughness properties (ρ, f)
- effective surface emissivities (as a function of wavelength)

I will present the current status of this project, together with the main achievments. The limitations are discussed in the context of current and future application of asteroids as calibrators.

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