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Sub-arcminute structure of the zodiacal emission

Cs. Kiss (1), **N. Szalai** (1), Z. Balog (2) and J. Stansberry (3)

(1) Konkoly Observatory, Budapest, Hungary, (2) Max-Planck-Institut für Astronomie, Heidelberg, Germany, (3) Steward Observatory, University of Arizona, USA

Abstract

In most directions the zodiacal emission dominates the brightness of the infrared sky in the 3...70 μm wavelength range. The absorption and scattering of solar radiation decreases the orbital velocities of the particles due to the Poynting-Robertson effect, limiting the lifetime of individual grains to $10^4 - 10^5$ years. The most likely source to replenish the evaporated dust is the destruction of comets and asteroids (see e.g. [6]). To determine the large scale structure of the IDC, the analysis of the global brightness distribution of the zodiacal light is the only available tool. The zodiacal emission was considered to be relatively smooth so far, i.e. lacking detectable irregularities as general characteristics (see [2], for a review). However, the brightness distribution of the zodiacal light contains substructures (asteroidal bands, cometary trails, rings of resonantly trapped dust) which carry important information on the origin of the interplanetary dust particles. For a clear cosmic infrared background (CIB) detection the zodiacal emission has to be separated from the other components of the infrared sky (galactic cirrus emission, extragalactic background light).

Previous studies probed the structure of the zodiacal emission down to the $3'$ scale ([1]) The relatively low spatial resolution of ISOPHOT, and the maximal spatial extension of the maps allowed to probe the $3'$...$30'$ spatial scale. For an aperture of $3'$ diameter an upper limit of $\pm$0.2% r.m.s. brightness fluctuations was found, which corresponds at high ecliptic latitudes to $\pm$0.04 MJy sr^{-1} at 25 μm, and this fluctuation power was found to be constant in the spatial scale investigated.

This information was widely used to constrain the detection of cosmic infrared background fluctuations at various wavelengths (see e.g. [3], [5]). Recent studies of CIB at near- and mid-infrared wavelenghts aimed to separate the different sub-components of the CIB, e.g. to detect the light of population III stars (e.g. [4]). These works used the extrapolated low spatial frequency information of the upper limits of the zodiacal emission fluctuations to determine the CIB fluctuations.

Due to their improved sensitivities compared with the present instrumentation, for the mid-infrared detectors of near future space astronomy missions (SPICA/SAFARI, JWST/MIRI) the observations will be limited only by the photon background of the zodiacal emission and by the confusion noise due to the background irregularities.

In our study we used the data of the following Spitzer programs: (i) "First Look Survey – Ecliptic Plane Component" (FLS_ECLIPTIC_PLANE/98); (ii) "The production of zodiacal dust by asteroids and comets" (ZODY/2317); (iii) "High latitude dust bands in the main asteroid belt: Fingerprints of recent breakup events" (HILAT/20539); (iv) "A new source of interplanetary dust: Type II dust trails" (T2T/30545). Our main aims are to determine the structure of the zodiacal emission available by the Spitzer/MIPS 24 μm measurements. Based on these data we derive power spectra and correlation functions in the target fields, calculate confusion noise, and apply models to reveal the nature of dust evolution in the interplanetary dust cloud.

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