Far-Infrared to Millimeter Astrophysical Dust Emission. II: Comparison of the Two-Level Systems (TLS) model with Astronomical Data

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In a previous paper we proposed a new model for the emission by amorphous astronomical dust grains, based on solid-state physics. The model uses a description of the Disordered Charge Distribution (DCD) combined with the presence of Two-Level Systems (TLS) defects in the amorphous solid composing the grains. The goal of this paper is to confront this new model to astronomical observations of different Galactic environments in the FIR/submm, in order to derive a set of canonical model parameters to be used as a Galactic reference to be compared to in future Galactic and extragalactic studies. We confront the TLS model with existing astronomical data. We consider the average emission spectrum at high latitudes in our Galaxy as measured with FIRAS and WMAP, as well as the emission from Galactic compact sources observed with Archeops, for which an inverse relationship between the dust temperature and the emissivity spectral index has been evidenced. We show that, unlike models previously proposed which often invoke two dust components at different temperatures, the TLS model successfully reproduces both the shape of the Galactic SED and its evolution with temperature as observed in the Archeops data. The best TLS model parameters indicate a charge coherence length of \simeq 13 nm and other model parameters in broad agreement with expectations from laboratory studies of dust analogs. We conclude that the millimeter excess emission, which is often attributed to the presence of very cold dust in the diffuse ISM, is likely caused solely by TLS emission in disordered amorphous dust grains. We discuss the implications of the new model, in terms of mass determinations from millimeter continuum observations and the expected variations of the emissivity spectral index with wavelength and dust temperature. The implications for the analysis of the Herschel and Planck satellite data are discussed.

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