

Extracting Asteroid Regolith Properties From Solar System Dust Bands

T. J. J. Kehoe^{1,2} and A. J. Espy Kehoe³

¹Florida Space Institute, 12354 Research Pkwy, Partnership 1 Bldg 8111, CPS 214, Orlando, FL 32826; thomas.kehoe@ucf.edu

²Departamento de Fisica da Universidade de Aveiro and CIDMA, Campus de Santiago, 3810-183 Aveiro, Portugal

³Department of Physical Sciences, Embry-Riddle Aeronautical University, 600 S. Clyde Morris Blvd, Daytona Beach, FL 32114

Abstract

By performing detailed dynamical modeling of the structure of a young, still forming, zodiacal dust band (Espy et al., 2009), we have shown that such partial dust bands retain significant information about both the size-frequency distribution and cross-sectional area of dust released in the disruption of their parent asteroids (Espy Kehoe et al., 2015). These observational constraints allow us to extract information regarding the properties of the regolith on the surface of the parent asteroid before its collisional disruption, including the depth of the regolith and the size-distribution of the particles present. In particular, using the constraints provided by modeling the faint partial dust band at an ecliptic latitude of 17° , we discuss the geotechnical properties of the surface regolith of the parent asteroid to the Emilkowalski cluster, and investigate the relationship between regolith depth and the size-distribution of particles.

For the young 17° partial dust band, we find a lower bound on the cumulative size-distribution inverse power-law index of 2.1, for dust particles with diameters ranging from a few μm up to a few cm, indicating that the cross-sectional area of ejected material is dominated by the smallest of these particles. Interestingly, this is a much steeper size distribution than the 1.2 cumulative inverse power-law index found for the older central and 10° bands (Grogan et al., 2001; Espy et al., 2010). This implies that small particles are being removed, as the dust band ages, at a faster rate (due to orbital decay caused by radiation forces) than they are being replenished (due to inter-particle collisions), and that results obtained from modeling older, fully-formed, dust bands will underestimate the contribution of small particles to the ejected regolith material.

Even though we determine the size distribution and regolith depth for the Emilkowalski parent asteroid using a markedly different method, we find striking agreement between our values and the values determined using in situ data of the surfaces of asteroids visited by spacecraft. Comparison of the regolith depth to parent body size for these asteroids yields an interesting trend. We find that the regolith depth scales linearly as 0.1% of the asteroid diameter for all asteroids for which measurements/models of the regolith depth exist, across over two orders of magnitude in the size range of the bodies. In addition to the regolith depth, we also find that the measured values for the

cumulative size-distribution index of the surface regolith particles on other asteroids are also in good agreement with the value found for Emilkowalski (>2.1). These results seem to imply that the dust released in the catastrophic disruption of an asteroid is dominated by the release of its surface regolith particles.

Knowing the size distribution of surface particles is critical for determining the cohesive properties of the asteroid regolith that is of vital importance for the success of many science and exploration missions such as NASA's OSIRIS-Rex and Asteroid Redirect Mission (ARM), JAXA's Hayabusa 2, and the joint ESA/NASA Asteroid Impact and Deflection Assessment Study (AIDA). Understanding the cohesive properties of regolith is crucial, for example, in determining if an asteroid surface will support the landing pads of a spacecraft, or for calculating the force required to leverage out a partially buried boulder — one of the stated goals of the ARM mission.