Photometry of the bright and dark terrains of Vesta and Lutetia with comparison to other asteroids

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The reflectance of a planetary surface as measured at different phase angles can provide useful information about several properties, both optical (importance of multiple and single scattering, regolith shadowing) and physical (roughness and regolith grain size). In particular, disk-resolved observations allow one to monitor photometric properties variations across a planetary surface. In this work, we retrieved disk-resolved phase functions of asteroids Vesta and Lutetia, by means of hyperspectral images returned by the Visible and InfraRed (VIR) mapping spectrometer onboard NASA's Dawn spacecraft, and the Visible, InfraRed, and Thermal Imaging Spectrometer (VIRTIS), onboard ESA's Rosetta spacecraft, respectively. Then we compared their photometric properties with those obtained of other asteroids closely explored by space missions (Gaspra, Ida, Eros, Annefrank, Steins, Mathilde). The trend of reflectance as a function of phase angle has been obtained by undertaking a statistical analysis, based on the empirical definition of reflectance families. For each family, the relation between reflectance and phase has been then calculated. On Vesta, we find steeper phase functions in dark material units, which become flatter with increasing albedo. This has been ascribed to a relevant role of multiple scattering in bright regions. As opposed to Vesta, Lutetia is a more homogeneous body. Hence we can consider a unique phase function for the whole asteroid surface. We chose two parameters useful to describe the photometric behavior of these asteroids: the reflectance which would be observed at a 30° phase, tagged R30, and the "phase slope" or the reflectance percent decrease between 20° and 60° phase, tagged PS. These two parameters have been calculated also on disk-resolved phase functions of other asteroids available in literature. We find that all S-type asteroids place in the same region of the R30-PS scatterplot, due to their similar photometric properties. C-type asteroids show the lowest R30 and the highest PS due to their low albedo and the negligible role of multiple scattering. On the contrary, the E-type asteroid Steins has a larger R30 and a lower PS. The R30 and PS parameters found in bright material units on Vesta are similar to those found for Steins, evidencing a photometric analogy between achondritic surfaces. We argued that the different photometric behavior of achondrites compared to chondrites is driven by their optical properties (i.e., larger albedo and efficiency of multiple scattering). Based on physical properties, Vesta should have a PS value similar to S-type asteroids (because its grain size is similar on average) or a larger one (since roughness is larger on Vesta). Dark material units on Vesta show an intermediate behavior between achondrites and C-type asteroids, confirming the fact that these regions are characterized by mixtures of HED and carbonaceous chondrites. The photometric properties of Lutetia (low R30 and low PS) cannot be grouped within other asteroid spectral classes. Since Lutetia is commonly classified as a C-type or an E-type, its surface should present physical or optical properties significantly different from other asteroids of its same class.