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Constraints on dust in Comet C/2012 J1 (Catalina) inferred from its color and polarimetric response

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We analyze photometric color and polarimetric image of Comet C/2012 J1 (Catalina) obtained on 15 November 2012 with the 6-m telescope (SAO RAS, Russia) [1]. The comet was observed at phase angle $\sim$14°, when it was at 3.17 AU from the Sun and 2.45 AU from Earth. Polarimetric images obtained with the V filter (λ = 0.5448 μm, $\Delta\lambda$ = 0.084 μm) reveals nearly constant negative polarization $P \approx$ –(2 $\pm$ 0.7)% at a projected distance from the nucleus $<$ 20,000 km. At greater distances, the negative polarization grows to $P \approx$ –(4–5)%. The color slope [2] computed at λ = 0.4845 μm and 0.6840 μm is equal to –7.6% per 0.1 μm implies blue color. The high-resolution spectrum of Comet Catalina suggests no significant gaseous emissions at these wavelengths. Therefore, the blue color of Comet Catalina can be attributed to its dust.

We model the shape of cometary dust using agglomerated debris particles that have highly irregular shapes and have been used to model light scattering from comets [e.g., 3]. We consider different refractive indices m that are representative of various cometary species, such as, ices, silicates, organics, and amorphous carbon. We also account for polydispersity of dust in the Catalina coma by averaging the light-scattering response over particle size using a power-law distribution.

Polarimetric images clearly suggest uniform dust characteristics at projected distances 0–20,000 km. The simplest approach solution assumes a single particle type having the same refractive index and size distribution throughout coma. We investigated this model and found that the polarization $P \approx$ –(2 $\pm$ 0.7)% can be reproduced by all materials with Im(m) $\leq$ 0.07. However, the color slope of –7.6% per 0.1 μm further constrains m. For instance, it is impossible to reproduce the observations with water ice, whose presence can be expected in Comet Catalina. However, we found that the polarization and the color slope can be simultaneously reproduced with m = 1.6 + 0.03i and power-law index of –3.2. This refractive index can be attributed to Mg-rich silicate slightly contaminated with amorphous carbon.

References

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