Comet C/2012 S1 (ISON)'s carbon-rich and micron-size-dominated coma dust

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Comet C/2012 S1 (ISON) was unique in that it was a dynamically new comet derived from the Nearly Isotropic Oort cloud reservoir of comets with a sun-grazing orbit. We present thermal models for comet ISON ($r_h \sim 1.15$ au, 2013-Oct-25 11:30 UT) that reveal comet ISON's dust was carbon-rich and dominated by a steep (and therefor narrow) grain size distribution (GSD) dominated by ∼ micron-sized grains. We constrained the models by our SOFIA FORCAST photometry at 11.1, 19.7 and 31.5 µm and by a silicate feature strength of ∼1.1 and an 8–13 µm continuum greybody color temperature of ∼275–280 K (using $T_{bb} \propto r_h^{-0.5}$ and T_{bb} ∼260–265 K from Subaru+COMICS, 2013-Oct-19 UT) [1,2]. Spectra of comet ISON with IRTF+BASS (2013-Nov-11-12 UT) also show a silicate feature strength of ∼1.1 as well as an 11.2 µm forsterite peak [3]. Our thermal models [6], which employ 0.1–1000 µm grains, yield constraints for the dust composition as well as GSD parameters of slope, peak grain size, porosity: ISON's dust has a low silicate-to-amorphous carbon ratio (∼1:9), the GSD has a steep slope ($N \simeq 4.5$), a peak grain radius of ∼0.7 µm, and moderately porous grains. Specifically, the 8–13 µm continuum color temperature implies submicron- to micron-size grains and the steep fall off of the SOFIA far-IR photometry requires the GSD to have fewer relative numbers of larger and cooler grains compared to smaller and hotter grains. A IR proxy for the dust production rate is $\epsilon f \rho$ ∼1500 cm [4], which is akin to but larger than Afρ in scattered light (2013-Oct-20 UT, Afρ=796 cm(±5 %) in V-band from Swift) [5]. Also, ISON had a moderate-to-low dust-to-gas ratio [6]. Comet ISON's dust composition and GSD properties are distinct from the few well-studied long-period Nearly Isotropic Comets (NICs) that all had 'typical' GSD slopes ($3.4 \leq N \leq 3.7$) and silicate-to-amorphous carbon ratios ≫1 as well as the following properties: C/1995 O1 (Hale-Bopp)[7,8,9,10] and C/2001 Q4 (NEAT)[11] had smaller and highly porous grains, whereas C/2007 N4 (Lulin)[12] and C/2006 P1 (McNaught)[13] had larger and compact porous grains. Radial transport to comet-forming disk distances (≥ 20 au) is easier for smaller grains than for larger grains (≤1 µm *vs.* ∼20 µm-like Stardust terminal particles) [14]. Perhaps Comet ISON formed either earlier in disk evolution whereby larger grains did not have the time to be transported to distances beyond Neptune, or the comet formed so far out in the disk that larger grains did not traverse such large radial distances. The high carbon-content of ISON's refractory dust appears to be complimented by the presence of limited-lifetime organic (CHON-like) grain materials: preliminary analyses of near-IR and high-resolution optical spectra indicate that gas-phase daughter molecules C_2, CN, and CH were more abundant than their parent molecules (HCN, C_2H_2, C_2H_6, measured in the near-IR) [15]. Dust composition as well as grain size distribution parameters (slope, peak grain size, and porosity) give clues to comet origins [16,17].

Acknowledgements: Based in part on observations made with the NASA/DLR Stratospheric Observatory for Infrared Astronomy (SOFIA) and financial support for this work was provided by NASA. Also, supported in part by the Aerospace Corporation's Independent Research and Development (IR&D) Program. We acknowledge the NASA Infrared Telescope Facility's support for the Comet ISON Observing Campaign (CIOC).

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