Dust Property on the Nucleus Surfaces of Short-Period Comets

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Since dust particles ejected form a comet are affected by radiation pressure from the sun as a function of their ratios of radiation pressure cross section to mass, the orbital evolution of the particles caused by the radiation pressure reveals the property of dust on the surface of a short-period comet nucleus. In the course of NASA's Deep Impact mission, the ejecta plume from the nucleus of comet 9P/Tempel 1 evolved under the influence of the radiation pressure. From the evolution and shape of the plume, we have found the β value is about 0.4, where β is the ratio of the radiation pressure to the solar gravity. From the fact that dust particles with $\beta \approx 0.4$ survives against the vapor pressure due to ice sublimation, the highest temperature that ice in the nucleus of comet 9P/Tempel 1 has undergone is estimated to be about 145 K. The temperature is much lower than that determined by the equilibrium between solar irradiation and its thermal emission, which implies existence of a surface dust layer with a low thermal conductivity that has kept the icy core at such a low temperature. In addition, taking into account $\beta \approx 0.4$ as well as the observational constraints of high color temperature and small silicate-feature strength, we conclude dust particles ejected from the surface dust layer of comet 9P/Tempel 1 are likely compact aggregates with mass $\sim 10^{-10}$ g, comparable to the major dust on the surface of comet 1P/Halley. Therefore, short-period comets are plausible to have surface dust layers mainly composed of compact dust aggregates with mass $\sim 10^{-10}$ g.