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On Water Ice in Cometary Outbursts

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Cometary outbursts are brief, but potentially strong, mass-loss events, likely caused by a wide range of phenomena [1]. Using near-infrared (near-IR) spectroscopy, water ice grains have been observed in the ejecta of some cometary outbursts. These detections present us with opportunities to study the properties of a cometary ice, and potentially infer the properties of the nucleus at the site of the event.

We present a detailed analysis of a large outburst (Δm~3 mag) of comet 243P/NEAT that occurred in December 2018, at 2.55 au from the Sun. Our study combines photometry, imaging, and spectroscopy with dynamical and thermophysical models of dust and ice grains. Overall, the outburst ejected ~10^8 kg of dust. We find no photometric or spectroscopic evidence for water ice in our data, which includes near-IR spectroscopy (1–2.5 µm) taken 4 days after the outburst. Nevertheless, this does not necessarily imply that water ice was not ejected by the outburst. Specifically, we consider the possibility that the ejecta from 243P had ice with the same properties as comet C/2013 US_{10} (Catalina): micrometer-sized grains mixed with a small fraction of low-albedo dust, ~0.5% by volume [2]. These physical properties can account for our 243P/NEAT observations on thermophysical and dynamical grounds, i.e., the icy grains are depleted in our spectroscopic slit due to ice sublimation and their expansion speed.

The lack of water ice absorption features in our near-IR spectrum is in stark contrast to the outbursts of comets 17P/Holmes and P/2010 H2 (Vales), which had the signatures of water ice 7 and 6 days post-outburst, respectively [3,4], despite occurring at similar heliocentric distances and spanning a wide range of ejected masses (10^8 kg for Vales, 10^{11} kg for Holmes) [5]. We consider the dynamical and thermophysical properties of water ice grains in each event, and discuss three possibilities for the differences: (1) that the site of the 243P outburst has a low abundance of water ice caused by surface processing or natal heritage; (2) that ice observed at Holmes and/or Vales was not from the original outburst, but instead produced after the event; and/or, (3) that a diversity of water ice properties exists in the comet population. We conclude that further studies of cometary outbursts that combine dynamical, spectroscopic, and thermophysical considerations will help advance our general understanding of water ice in comets.

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