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Modeling of Jet Formation on Comet 103P/Hartley 2

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Abstract

Images obtained with the Deep Impact Flyby spacecraft's Medium-Resolution Instrument (MRI) and High-Resolution Instrument (HRI) during the EPOXI mission's closest approach to comet 103P/Hartley 2 reveal the existence of numerous highly collimated, active, filamentary structures emanating from the nucleus. The jet activity on Hartley 2 can be traced to distinct types of geological features, such as along scarps, fractures, and depressions [1], providing compelling evidence for a connection between nucleus geology and the formation and evolution of jets. These observations, combined with insight to how the outgassing of CO_2 appears to entrain aggregates of H_2O ice [2], place new constraints on the geometry of jet source regions, as well as the composition and dynamics within these flows.

Based upon the premise that surface-controlled processes may contribute to jet formation, we have run simulations of cometary jet activity using CALE [3], a 2-D Arbitrary Lagrangian Eulerian hydrodynamical code developed by Lawrence Livermore National Laboratory (LLNL). The setup for our numerical study is based loosely on the qualitative model for the evolution of a vent suggested in [4], where a structural weakness within the comet's dusty mantle leads to a slumping of warm material into underlying frozen volatiles and a resulting activation of the jet. Results from models using various vent geometries suggest that the mechanism for collimation may be tied to the depth-to-width ratio of the vent. As time elapses, the width of the source region expands. Source regions that are enriched in highly volatile CO_2 are observed to remain more tightly collimated. Entrained dust and water ice particles comprise the majority of the collimated portion of the flow, while CO_2 appears to drive the process. Acceleration near the surface is sufficient to entrain μm-sized grains, which is consistent with theoretical calculations for scattering by icy grains in [2].

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