Three-dimensional multi-fluid modeling of comets 1P/Halley and 26P/Grigg-Skjellerup and comparison with the Giotto data

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The motivation to understand the physical and chemical composition of the cometary nucleus has led to several recent missions that followed the groundbreaking in situ investigations of comet 1P/Halley in 1986 and comet 26P/Grigg-Skjellerup in 1992 by the Giotto spacecraft. Numerical models of the interaction between the solar wind and the cometary atmosphere are needed to support ongoing missions and new mission planning, and also to advance the understanding of the physics and dynamics of the cometary coma.

Here we describe the results of our CASIM3D model for comet 1P/Halley and comet 26P/Grigg-Skjellerup as the Giotto spacecraft observed them during the 1986 and 1992 flybys.

The CASIM3D code is based on the solution of the multi-fluid MHD equations using an efficient adaptively refined Cartesian mesh solver. The code developed for high performance parallel processing computers, combines the high spatial resolution of smaller than one kilometer grid spacing near the nucleus, with a large computational domain that enables structures nearly 10 million km down the comet tail to be modeled. Ions, neutrals, and electrons are considered as separate interacting fluids. Significant physical processes treated by the model include both photo and electron impact ionization of neutrals, recombination of ions, charge exchange between solar wind ions and cometary neutrals, and frictional interactions between the three fluids considered in the model.

We show that CASIM3D successfully provides a three-dimension steady state solution for the coma proprieties of both comets where density, velocity, and temperatures of ions, neutrals, and electrons are self-consistently and independently computed. The cometary parameters and structure derived from our code agrees satisfactorily with past models. The comparison data from the Giotto instruments shows a good agreement between the model and the measurements for a variety of parameters over a range of spatial scales.