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Constraining ion transport in the diamagnetic cavity of comet 67P

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Comets are small icy bodies originating from the outer solar system that produce an increasingly dense gas coma through sublimation as they approach perihelion. Photoionisation of this gas results in a cometary ionosphere, which interacts with the impinging solar wind, leading to large scale plasma structures. One such structure is the diamagnetic cavity: the magnetic field-free inner region that the solar wind cannot penetrate. This region was encountered many times by the ESA Rosetta mission, which escorted comet 67P/Churyumov-Gerasimenko for a two-year section of its orbit.

Within the diamagnetic cavity, high ion bulk velocities have been observed by the Rosetta Plasma Consortium (RPC) instruments. The fast ions are thought to have been accelerated by an ambipolar electric field, but the nature and strength of this field are difficult to determine analytically. Our study therefore aims to model the impact of various electric field profiles on the ionospheric density profile and ion composition. The 1D numerical model we have developed includes three key ion species (H₂O⁺, H₃O⁺, and NH₄⁺) in order to assess the sensitivity of each to the timescale of plasma loss through transport. NH₄⁺ is of particular interest, as it has been previously shown to be the dominant ion species at low cometocentric distances near perihelion. It is only produced through the protonation of NH₃, a minor component of the neutral gas, and we show that this makes it particularly sensitive to the electric field.

We also compare the simulated electron density to RPC datasets, to find the electric field strength and profile which best recreate the plasma densities measured inside the diamagnetic cavity near perihelion. From this, we also constrain the radial bulk ion speed that is required to explain the observations with the model.