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Solar wind protons in the diamagnetic cavity at comet 67P/Churyumov-Gerasimenko

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Against expectations, the Rosetta spacecraft was able to observe protons of solar wind origin in the diamagnetic cavity at comet 67P/Churyumov-Gerasimenko. This study investigates these unexpected observations and gives a working hypothesis on what could be the underlying cause.

The cometary plasma environment of a comet is shaped by two distinct plasma populations: the solar wind, consisting of protons, alpha particles, electrons and a magnetic field, and the cometary plasma, consisting of heavy ions such as water ions or carbon dioxide ions and electrons.
As the comet follows its orbit through the solar system, the amount of cometary ions that is produced varies significantly. This means that the plasma environment of the comet and the boundaries that form there are also dependent on the comet's heliocentric distance.

For example, at sufficiently high gas production rates (close to the Sun) the protons from the solar wind are prevented from entering the inner coma entirely. The region where no protons (and other solar wind origin ions) can be detected is referred to as the solar wind ion cavity.
A second example is the diamagnetic cavity, a region very close to the nucleus of the comet, where the interplanetary magnetic field, which is carried by the solar wind electrons, cannot penetrate the densest part of the cometary plasma.

The Rosetta mission clearly showed that the solar wind ion cavity is larger than the diamagnetic cavity at a comet such as 67P/Churyumov-Gerasimenko. However, this new study finds that in isolated incidences this order can be reversed and ions of solar wind origin (mostly protons, but also helium) can be detected inside the diamagnetic cavity. We present the observations pertaining to these events and list and discard possible mechanisms that could lead to such a configuration. Only one mechanism cannot be discarded: that of a solar wind configuration where the solar wind velocity is aligned with the magnetic field. We show evidence that fits this hypothesis as well as solar wind models in support.