The theory of the diamagnetic cavity – a post Rosetta revision

Zoltan Nemeth (nemeth.zoltan@wigner.mta.hu)
Wigner Research Centre for Physics, Konkoly-Thege M. Rd. 29-33 Budapest, Hungary

Recent observations of the Rosetta mission provide comprehensive plasma data about a multitude of diamagnetic cavity crossing events and reveal a surprisingly large diamagnetic cavity around comet Churyumov-Gerasimenko featuring an unforeseen, rich and very dynamic structure. The classical description of the cavity – although very successful in explaining many aspects of the observations – concentrates on solving a single equation in the long distance and zero resistivity limit. It turns out that exact analytical solutions of the complete set of equations exist for a more general case. These solutions provide new insights into the properties and dynamics of the phenomenon. The generalized solutions show that the magnetic field does not drop to zero immediately inside the cavity, but features a rapid exponential decay instead. Outside the cavity as the distance increases the magnetic field approaches the classical solution. The plasma velocity first drops rapidly as the plasma enters the cavity boundary; for larger distances it decreases as 1/r towards its asymptotic value. We can find inward and outward moving solutions possessing distinctly different properties and explaining the dynamic nature of the cavity. The plasma density has a peak just outside the cavity, the density enhancement is more pronounced for weak comets, resulting in stronger then expected interaction and larger cavity.