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A dusty plasma model for characteristics of vortices in Jupiter's atmosphere

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Various characteristic features of self-organized vortices such as Great Red Spot (GRS) and White Ovals of Jupiter's atmosphere are analyzed using a 2D hydrodynamic model for an electrostatically bounded charged dust cloud in an unbounded streaming plasma. For a bounded domain relevant to the geometry of GRS, and a driving sheared ion flow similar to the part of zonal jets streaming through the vortices, the steady-state solutions of the 2D hydrodynamic model reveal many common characteristic features between the steadily driven dust circulation in laboratory experiments and the vortices in Jupiter's atmosphere. The continuous structural changes of GRS and the persistence of high-speed collar rings around the quiescent interiors of the vortices are all demonstrated as a consequence of changes in internal properties governed by the kinematic viscosity rather than the driving fields. In addition, a novel method for estimating the range of kinematic viscosity of Jupiter's atmosphere is proposed from the observed flow fields. This analysis also sheds light on the roles of the driving field, boundaries, and dynamical parameter regime in determining the characteristic size, the strength, the circulating direction, and the drift of the vortices in Jupiter's atmosphere and potentially other relevant driven-dissipative flow systems in nature.

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