# The Implications of Electrical Conductivity Models of Uranus and Neptune

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Recent studies show that planetary “ices” such as water and ammonia become ionically conducting under conditions present in Uranus and Neptune. Moreover, within the ionic liquid regime of water present in the outer layers of the planets, dissociation of hydrogen in H2-H2O mixtures has a significant ionic contribution to electrical conductivity. At the same time, the interiors of Uranus and Neptune are poorly constrained, and can be fitted with varying amount of ice-to-rock ratios, challenging the view of Uranus and Neptune being “ice giants”. Understanding the behaviour of electrical conductivity within Uranus and Neptune has a direct implication on understanding their observed multipolar and non-axisymmetric magnetic fields, the extents of their dynamo generation region, their composition, and the complex secondary fields due to the background magnetic field-zonal flow coupling. We present a method for calculating electrical conductivity profiles of ionically conducting H2-He-H2O mixtures using results from ab initio simulations. We then apply this prescription on several published interior structure models of Uranus and Neptune. We find that the conductivity increases rapidly with depth in the outer 20% for both planets. With rapidly increasing electrical conductivity, fast zonal winds on Uranus and Neptune inevitably couple to the background magnetic field, inducing electrical currents and magnetic field perturbations spatially correlated with zonal flows. Induced currents generate Ohmic dissipation, which can be used to constrain the depth of the zonal winds when considering the energy/entropy flux budget throughout the planetary interior. Constraining the zonal wind decay is not only important for understanding the atmosphere dynamics on Uranus and Neptune, but can also be used to estimate the strength of magnetic field perturbations. We find that the poloidal component of these perturbations can reach O(0.1) of the background magnetic field in strength, depending on the temperature profile of the planets. We suggest that these effects could be detectable by the future flagship mission to Uranus.