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The manifold zoology of anelastic dynamos with variable conductivity

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Whereas the dynamo processes in terrestrial planets is strongly influenced by the overlying rocky mantle, the induction of global magnetic fields in gas giants is mainly affected by internal properties, such as the rapid outward decay of static density, pressure and temperature throughout the gaseous shell. Further for Jupiter and Saturn it is well known that the transition from metallic to molecular hydrogen leads to a steep decrease in the electrical conductivity. This drop-off radius is closer to the surface for heavy Jupiter (at 90% of its respective radius), but much deeper for the less massive Saturn (65%). From the modelling perspective this leads to an inner conducting shell where the magnetic fields dominate the dynamics, and outer hydro dynamic shell where the strong Coriolis force reigns.

Within this study we parametrise the conductivity drop-off radius and investigate the interaction between these shells, such as the emergence of differential rotation and induction of magnetic fields. Remarkably, we could identify numerous rather different self-consistent dynamo solutions. E.g., hemispherical dynamos, quadrupolar dynamos, octupolar dynamos, dipolar dynamo waves or many mixed modes, such as solutions where the quadrupole is stable in time and the dipole periodically reverses.

In summary, our results suggest anelastic dynamo models with variable conductivity yield manifold different solutions in close poriximity in the parameter space. Unfortunately for Saturn-like models with deep conductivity drop-off, Saturn-like magnetic field (stable, strongly dipolar) seemed rather unlikely.