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Differential flow in planets prior to core formation

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Differential rotation in the outer core plays an important role in the formation and maintenance of the Earth's magnetic field. The Earth's liquid outer core experiences a change of only 0.2 density scale heights with depth and is therefore usually modeled as a Boussinesq fluid. While this density change is small, 3D simulations do differ from constant density simulations (G. Glatzmaier, personal communication). Differential rotation in 3D Boussinesq simulations is maintained by vortex stretching of convective fluid columns due to the sloping impermeable boundaries. Meanwhile, 2D anelastic simulations of rotation in the equatorial plane show that differential rotation can form via local generation of vorticity as fluid parcels move radially, expanding or contracting with respect to the background density stratification. Constant density (Boussinesq) simulations in the same 2D geometry, of course, do not generate differential rotation. The question is then, in a 3D anelastic body, what is the relative importance of the density stratification to jet formation? Further, do multiple jet structures arise in anelastic bodies under conditions that would not form multiple jets in a Boussinesq body, i.e. in bodies without solid cores, prior to the formation of a solid inner core? This study looks at three-dimensional numerical simulations of thermal convection in inertial, rotating spherical fluid bodies with and without density stratification to explore the role of density stratification on generating and maintaining a zonal flow without a solid inner core.