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Convective scale and subadiabatic layers in deep stellar convection zones

The overall understanding of solar and stellar convection has been questioned during the last decade or so with helioseismic results suggesting that the convective amplitudes at large horizontal scales in the Sun might be much lower than indicated by current simulations or mixing length estimates. A manifestation of this ``convective conundrum'' is that global simulations struggle to reproduce a solar-like differential rotation with a fast equator and slow poles with nominally solar parameters. A major contributor to this is that giant cell convection, with characteristic length scale comparable to the depth of the convection zone, is excited in simulations but appears to be much weaker in the Sun. Our inability to model convection accurately is arguably the main problem hindering current global 3D simulations in reproducing solar and stellar dynamos.

A possible solution to this conundrum is that a large fraction of the solar convection zone is weakly stably stratified due to plumes originating near the surface and piercing the whole convection zone, such that giant cells are not excited. Non-rotating numerical simulations lend support to such non-local scenario of convection and lead to sizeable Schwarzschild-stable, yet convecting, layers in deep convection zones. Another possibility is that convection is rotationally constrained such that horizontal extent of convection cells is significantly reduced.

New results from hydrodynamic rotating Cartesian convection simulations are presented that seek to capture the rotationally constrained convection near the base of the solar convection zone. The current results indicate that in models corresponding to the deep parts of the solar convection zone, the subadiabatic and overshoot layers are somewhat shallower than in the non-rotating case. Furthermore, these simulations suggest that deep convection in the Sun is not strongly rotationally constrained and that rotational suppression of large scale flows is weak.