Realistic numerical simulations of solar convection: emerging flux, pores, and Stokes spectra

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We report on magneto-convection simulations of magnetic flux emerging through the upper layers of the solar convection zone into the photosphere. Simulations by Georgobiani, Stein and Nordlund start from minimally structured, uniform, untwisted horizontal field advected into the computational domain by supergranule scale inflows
at 20 Mm depth. At the opposite extreme, simulations by Cheung (2007, 2008, 2011) start with a coherent flux tube inserted into or forced into the bottom of the computational domain.

Several robust results have emerged from the comparison of results from these two very different initial states. First, rising magnetic flux gets deformed into undulating, serpentine shapes by the influence of the convective up- and down-flows. The flux develops fine structure and appears at the surface first as a "pepper and salt" pattern of mixed polarity. Where magnetic flux approaches the
surface, granules become darker and elongated in the direction of the field. Subsequently, the underlying large scale magnetic structures make the field collect into unipolar regions.

Magneto-convection produces a complex, small-scale magnetic field topology, whatever the initial state. A heirarchy of magnetic loops corresponding to the different scales of convective motions are produced. Vertical vortex tubes form at intergranule lane vertices which can lead to tornado-like magnetic fields in the photosphere. Gradients in field strength and velocity produce asymmetric Stokes
spectra. Where emerging Omega loops leave behind nearly vertical legs, long lived pores can spontaneously form. The field in the pores first becomes concentrated and evacuated near the surface and the evacuated flux concentration then extends downward.