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High-performance simulations of turbulent planetary dynamos

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Understanding the dynamics of planetary interiors is essential for explaining magnetic-field generation, thermal evolution, orbital history, and observable signatures across the Solar System and exoplanets. These regions host strongly nonlinear flows driven by rotation and buoyancy, but also by tides, precession, or double-diffusive effects. They operate in extreme parameter regimes far beyond laboratory capabilities, making high-performance simulations a key tool to connect theory with observations.

In this talk, I will present recent advances in modeling turbulent planetary interiors using the XSHELLS code, a massively parallel magneto-hydrodynamic solver for spherical geometries. After introducing the physical motivations, I will describe the numerical approach and how XSHELLS allows us to reach turbulent, low-diffusivity regimes relevant to planetary conditions. I will then illustrate applications ranging from dynamos in liquid planetary layers to semi-convection driven magnetic fields in giant planets.

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