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The Sphered Cube and other applications of sparse spectral methods in spheres KEATON BURNS, Center for Computational Astrophysics, Flatiron Institute, DANIEL LECOANET, Princeton University, GEOFFREY VASIL, University of Sydney, JEFFREY OISHI, Bates College, BENJAMIN BROWN, University of Colorado Boulder, ERIC HESTER, University of Sydney
— Developing efficient spectral discretizations of hydrodynamical models in spherical coordinates is a challenging task. For instance, the analytical behavior of scalars, vectors, and tensors differ near the coordinate singularities at the poles and the origin, so care must be taken to maintain accuracy in spectral representations of such quantities. We have recently developed bases for arbitrary-order tensors in the ball that incorporate these different analytical behaviors and possess banded differential operators similar to sparse Chebyshev methods. These new bases enable the efficient and systematic discretization of broad ranges of tensorial PDEs in spherical coordinates. We will discuss these bases and their implementation in the open-source spectral framework Dedalus. We will then present a variety of uncommon simulations in spherical domains, including Rayleigh-Benard convection in a cube using immersed boundaries, and the evolving interface between an ice shell and an underlying ocean using the phase-field method. These examples illustrate the robustness of these spherical bases and their utility for complex simulations of stellar and planetary interiors.

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