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The effect of subfilter-scale physics on regularization models

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The subfilter-scale (SFS) physics of regularization models are investigated to understand the regularizations' performance as SFS models. The strong suppression of spectrally local SFS interactions and the conservation of small-scale circulation in the Lagrangian-averaged Navier-Stokes alpha-model (LANS-alpha) is found to lead to the formation of rigid bodies. These contaminate the superfilter-scale energy spectrum with a scaling that approaches k^1 as the SFS spectra is resolved. The Clark-alpha and Leray-alpha models, truncations of LANS-alpha, do not conserve small-scale circulation and do not develop rigid bodies. LANS-alpha, however, is closest to Navier-Stokes in intermittency properties. All three models are found to be stable at high Reynolds number. Differences between L^2 and H^1 norm models are clarified. For magnetohydrodynamics (MHD), the presence of the Lorentz force as a source (or sink) for circulation and as a facilitator of both spectrally nonlocal large to small scale interactions as well as local SFS interactions prevents the formation of rigid bodies in Lagrangian-averaged MHD (LAMHD-alpha). We find LAMHD-alpha performs well as a predictor of superfilter-scale energy spectra and of intermittent current sheets at high Reynolds numbers. We expect it may prove to be a generally applicable MHD-LES.

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