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Catastrophic quenching in alpha-Omega dynamos revisited

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At large magnetic Reynolds numbers, magnetic helicity evolution plays an important role in astrophysical large-scale dynamos. The recognition of this fact led to the development of the dynamical alpha quenching formalism, which predicts catastrophically low mean fields in open systems. Here we show that in oscillatory alpha-Omega dynamos this formalism predicts an unphysical magnetic helicity transfer between scales. An alternative technique is proposed where this artifact is removed by using the evolution equation for the magnetic helicity of the total field in the shearing--advective gauge. In the traditional dynamical alpha quenching formalism, this can be described as an additional magnetic helicity flux of small-scale fields that does not appear in homogeneous alpha-squared dynamos. In alpha-Omega dynamos, the alternative formalism is shown to lead to larger saturation fields than previously obtained with the traditional formalism.

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