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A second look at zonal flows[1]

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Despite the fact that the paradigm of self-regulating drift wave-zonal flow turbulence is over fifteen years old, many relevant fundamental questions remain. In particular, nearly all the theoretical work on zonal flow generation has approached the problem via an essentially linear modulational analysis of some pre-existing turbulent state. In this talk, we report on exact momentum theorems which constrain the zonal flow and wave momentum (pseudomomentum), and relate flow evolution to the driving flux, potential enstrophy, dissipation, etc., as well as flow drag. These theorems are derived for both reduced fluid and gyrokinetic models, and severely constrain possible zonal flow growth, via the zonal momentum budget. Since the zonal momentum balance includes potential enstrophy convergence, turbulence spreading dynamics is intrinsically coupled to zonal flow momentum. Results for spreading, collisionless saturation and zonal flow evolution in flux-driven systems will be discussed. The relation between kinetic pseudomomentum and dynamic pressure in kinetic energy principles for self-gravitating systems has been determined and will be presented, along with implications for phase space granulation evolution.

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