Role of Stable Eigenmodes in Anomalous Momentum Transport

P.W. Terry D.R. Hatch and D.A. Baver
University of Wisconsin-Madison

At saturation turbulent transport fluxes often develop a nonlinear cross phase in which the response of a transported fluctuation to advecting flow is no longer well described by linear theory. The nonlinear response can be decomposed into a basis set of linear eigenmodes with amplitudes governed by nonlinear mode coupling. If the cross phase is nonlinear, finite-amplitude contributions from eigenmodes other than the most unstable eigenmode are present. Typically this involves stable eigenmodes. This type of physics has been demonstrated for a variety of simple models, including 2D models for trapped electron mode turbulence and ion-temperature-gradient-like turbulence.[1] There is also evidence it operates in comprehensive models.[2] Stable eigenmodes whose damping rate is no larger than the growth rate of the instability are particularly apt to reach finite levels of excitation in saturation, and modify transport cross phases.

We are interested in the effect of stable eigenmodes on the flux of parallel momentum, its relationship to the heat flux, and its relationship to mean gradients. To make contact with prior work we study a very simplified 2D model for ion-temperature-gradient-like turbulence that has been shown to have significant stable eigenmode excitation. We examine the case of weak to moderate mean flow gradient (moderate to large Richardson number).[3] The quasilinear momentum flux is driven primarily by the pressure gradient (off diagonal) and is negative. There are two stable eigenmodes in this problem, a damped eigenmode that is nearly the complex conjugate of the unstable eigenmode, and a neutrally stable eigenmode.

Simulations show that both stable eigenmodes are excited, and that they significantly change the quasilinear fluxes for both momentum and heat, primarily by reducing the fluxes. However, there are other effects. The neutral eigenmode only contributes to the momentum flux through cross correlations with the unstable and stable eigenmodes. Symmetry in the problem makes these correlations cancel most of the time. However, the flux is bursty, and when the quasilinear flux is maximum the cancelation is not complete. At these times the momentum flux reverses sign. Variations in the heat and momentum fluxes generally are well correlated, except during the sign reversals.

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[3]N. Mattor and P.H. Diamond, Phys. FLuids **31**, 1180 (1988).