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Mean Field Theory for Turbulent Transport of Momentum in the Solar Tachocline PEI-CHUN HSU, UCSD, PATRICK DIAMOND, UCSD; NFRI, Korea — Zonal flow formation is mainly studied in wavenumber space, i.e., as transfer of kinetic energy between scales. A description based on momentum transport in real space is in many cases more useful. The physics of turbulent momentum transport in the solar tachocline is not clear; different models assume different roles of turbulence such as constant positive or negative viscosity. Here we show that turbulent transport of momentum cannot be simply described as a Fickian diffusion process; it is sensitive to flow structure, and the transport coefficients are functions of flow shears. In this work we consider the general structure of the momentum flux for a 2D quasi-geostrophic system. A modulational calculation of the momentum flux reveals both a negative turbulent viscosity and a positive turbulent hyper-viscosity. While the negative viscosity phenomenon of zonal flow growth by Reynolds work is generally known, positive hyper-viscosity accounts for the saturation mechanism of zonal flow growth, which can originate from a cut-off scale from coarse graining wave packets. To address more realistic problems, large-scale mean shear flows are included to the zonal flow-wave turbulence system and the corresponding structure of momentum flux is obtained using the method of characteristics.

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