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Reverse Trend of Turbulent Transport Coefficients in Strong Gradient Fusion Plasmas

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It is of great interest to study the turbulent transport under strong plasma gradient, which is a prominent feature of the typical pedestal plasma. First principle gyrokinetic simulation of the turbulent transport under strong gradient using the GTC code with HL-2A experiment parameters finds that the turbulent transport coefficient decreases with the applied gradient, which is contradictory to the conventional wisdom for the transport coefficient trend under weak gradient [1]. This extraordinary behavior is not related to the zonal flow regulation. Instead it is found to stem from the eigenmode structure change under strong gradient [2,3], where the most unstable micro-instabilities are non-ground eigenstates with unconventional mode structures [2,4,5] which significantly reduces the effective correlation length and thus reverses the transport trend. Both linear and nonlinear critical gradients are found to exist, which contributes to such non-monotonical transport behavior [3]. In addition, the frequency from the simulation agrees with the HL-2A experiment [6]. By including the inverse cascade effect during the nonlinear saturation, the nonlinear poloidal spectrum can also match the experimental observation.

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Figure: Reverse trend of turbulent transport coefficient under strong gradient