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Theory of turbulent saturation in stellarators: identifying mechanisms to reduce turbulent transport[1] C. C. HEGNA, P. W. TERRY, B. J. FABER, University of Wisconsin-Madison — A theory for ion temperature gradient (ITG) turbulent saturation in stellarators is developed using a three field fluid model that allows for general 3D geometry. The model relies on the paradigm of nonlinear energy transfer from unstable to damped eigenmodes at comparable wavelength as the dominant saturation process. This mechanism is enabled by a three-wave interaction where the third mode primarily regulates the nonlinear energy transfer rate and depends upon the properties of the magnetic geometry. In particular, this work suggests that quasi-helically symmetric configurations may have an intrinsic advantage with regard to turbulent saturation physics relative to other configurations as multiple energy transfer channels can be exploited. Nonlinear energy transfer physics is quantified by the product of a turbulent correlation lifetime as computed from a three-wave frequency mismatch and a geometric coupling coefficient with larger turbulent correlation times denoting larger levels of nonlinear energy transfer and hence smaller turbulent transport. The theory provides an analytic prediction for how 3D shaping can be tuned to lower turbulent transport through saturation processes that can by used in optimization schemes for improved stellarator design.

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