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Abstract for an Invited Paper
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A New Paradigm of Plasma Transport and Zonal Flows[1]

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First, a set of experiments to explore the isotope scaling paradox is described and a new paradigm is proposed. Most tokamak experimental results indicate dependence of the ion thermal conductivity on the isotopic mass close to $\chi_\perp \sim A_i^{-0.5}$, i.e., inverse gyro-Bohm. This is in stark contradiction to most present theoretical models predicting Bohm (A_i^0) or gyro-Bohm ($A_i^{0.5}$) scaling. A basic physics experiment [1] on the anomalous ion thermal conduction due to ion temperature gradient instabilities in two different gases (hydrogen and deuterium) closely confirms the tokamak results. Another series of experiments designed to explore the physics basis of this scaling appears to lead to a new model for this scaling based on 3-wave coupling of two ion temperature gradient radial harmonics and an ion acoustic wave. The resulting isotopic scaling of transport is $\sim A_i^{-0.5}$ dictated primarily by the ion acoustic damping. This basic physics is deemed to be extrapolatable to tokamaks resolving the paradox [2]. Secondly, the much discussed theoretical role of zonal flows in transport regulation is critically examined by another set of experiments [3]. Direct detection of zonal flows in tokamaks has been nearly impossible rendering its widely believed role experimentally unverified. A novel diagnostic has been developed by the observation that the effect of zonal flow can be seen as the FM modulation (at zonal flow frequency) of the carrier frequency of the large equilibrium Doppler shift frequency of ITG modes both in tokamaks and CLM. The experimental results indicate zonal flow levels roughly of the order of our model prediction. However, the experimental shear level is much lower than that predicted by the present theories for transport regulation. This research was supported by U.S. Department of Energy Grant No. DE-FG02-98ER-54464.

References

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