IAEA FEC 2014

Contribution ID: **278** Type: **Poster**

Electron Temperature Critical Gradient and Transport Stiffness

Tuesday 14 October 2014 14:00 (4h 45m)

In a continuing effort to validate turbulent transport models, the electron heat flux has been probed as a function of electron temperature gradient on the DIII-D tokamak. In the scan of gradient, a critical electron temperature gradient has been found in the electron heat fluxes and stiffness at various radii in L-mode plasmas. The TGLF reduced turbulent transport model [G.M. Staebler, J.E. Kinsey, and R.E. Waltz, Phys. Plasmas 14, 055909 (2007)] and full gyrokinetic GYRO model [J. Candy and R.E. Waltz, J. Comput. Phys. 186, 545 (2003)] obtain the observed critical gradients and stiffnesses, but they do not predict the absolute level of transport at all radii. Here the stiffness is defined as the ratio of the heat pulse diffusivity (obtained by modulating 1 of the electron cyclotron heating gyrotrons) to the power balance diffusivity. For a regime where the heat flux is linearly proportional to the temperature gradient (with no offset), the stiffness is 1. There can be a critical gradient above which the flux is no longer proportional to the gradient; the stiffness will then jump above 1. Consistent with a critical gradient paradigm, the inferred stiffness at each radial location starts around 1 and jumps up above 1 at a critical gradient. The value of the critical gradient is observed to increase with radius in the plasma. The TGLF and GYRO predicted fluxes and stiffnesses exhibit a similar critical gradient; however there are conditions, such as when the experimentally inferred fluxes are large compared to gyrobohm fluxes, under which both codes underpredict the baseline level of transport. In addition to inferring the power balance and heat pulse diffusivities, the electron temperature fluctuations were measured at ρ=0.6 using the Correlated Electron Cyclotron Emission diagnostic. Although the GYRO code does reasonably well at predicting the fluxes at this radius, it substantially underpredicts these electron temperature fluctuations, while still exhibiting a critical gradient similar to the measured fluctuations. This is a quandary because, in the past, predicted fluxes and fluctuations either both agree or disagree with experiment. The nature of the experiment-code discrepancies is prompting reevaluation of the range of wavenumbers used in GYRO simulations.

This work was supported by the US Department of Energy under DE-FC02-04ER54698.

Paper Number

EX/P2-29

Country or International Organisation

USA

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Session Classification: Poster 2