Electron Transport analysis of a four-phase TCV H-mode

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A high power electron cyclotron resonance heating (ECRH) plasma in the Tokamak à Configuration Variable (TCV) is analyzed for turbulent electron transport. The high central power deposition of ECRH ($5-8\ \mathrm{MW/m^3}$) to the electrons and no auxiliary ion heating makes TCV shot 29892 particularly well suited for studies of the electron transport. In addition, this shot contains four distinct H-mode phases. The initial ohmic H-mode with type III ELMs switches to a type I ELMy H-mode when the ECRH is turned on. As the ELMs are suppressed, the plasma enters a quasi-stationary ELM-free H-mode. A single ELM event triggers an m/n=3/2 MHD mode, which lowers the confinement $\sim 15\%$ but the quasi-stationary ELM-free H-mode persists.

The analysis shows that the trapped electron (TEM) transport has problems in explaining both the magnitude and radial profile of the transport. Either the electron temperature or density gradient can drive the TEM mode depending on the collisionality regime. In some cases, a raise in $\boldsymbol{\nabla} T_e$ can even suppress TEM growth. The TEM response function is shown to be relatively small and have sharp resonances in its energy dependence. The electron temperature gradient (ETG) mode, on the other hand, is driven by $\boldsymbol{\nabla} T_e$ and both passing and trapped electrons contribute to the instability and to electron thermal heat flux q_e. It is shown that the out-of-phase component of the electron response function is large and lacks sharp resonances in its energy spectrum. This difference makes the ETG formulas more widely applicable to the broad range of plasma parameters in TCV 29892.

The ETG model is based on the three coupled gyrofluid partial differential equations, whose linear modes describe well the ETG instability. The non-linear simulations show that the small scale fluctuations created at the maximum linear growth rate undergo an inverse cascade to form large scale structures. The produced thermal diffusivity is suitably large and scales as the power balance data.