ITB formation from velocity and magnetic shear

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Physics issues

Velocity and magnetic shear are thought to lead to ITB formation by breaking up turbulent eddies and/or reduction in the growth rates of micro-instabilities. Sheared rotation is usually accomplished through neutral beam injection, while magnetic shear is most commonly obtained by current ramping, as well as ECCD and LHCD. ITBs have recently been produced using ICRF MCFD to produce the velocity shear. ITBs have also been produced with off-axis ICRF minority heating, although the paradigm of velocity and magnetic shear may not be at play in this case. ITBs have also been observed following pellet injection, sometimes develop spontaneously in Ohmic H-mode discharges, and the role of magnetic and velocity shear in these cases is not so clear. Rational q surfaces are well known to play an important role in ITB formation, but the details of the mechanism are not clear.

Research Requirements

Looking to future reactor relevant regimes, NBI may not be available for providing the velocity shear, and other RF techniques will become necessary. Clarification of which aspects of NBI are relevant for ITB formation (for example velocity shear vs. energetic particles) would be a useful exercise. Furthermore, for steady state ITBs, current ramping to induce magnetic shear will not be an option, and the use of LHCD, ECCD or other current drive methods will be required. Another concern is that most of the current ITB formation techniques only work at low density, in regimes with decoupled electrons and ions, which is not necessarily relevant to reactor conditions. Exploration of electron ITBs would be more appropriate. A worry is that if the ITB is too strong, a β limit will be approached. Two critical issues are control of the ITB foot location, to optimize the bootstrap current, and the regulation of impurities, which often accumulate following ITB formation. (see Particle and Impurity Transport and Fuelling, W.Rowan)

Research Thrusts

Explore ITB formation without neutral beam injection, without current ramping and at high densities. May require expanded electron heating capabilities. Continue work on ITB formation using ICRF MCFD.

Develop techniques for ITB foot position control using RF tools.

Improve theoretical understanding of ITB formation mechanism.

Improve measurements of q profiles with diagnostic upgrades.