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PhD PROPOSAL 2012

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Title : Fast particle effect on plasma rotation in tokamaks

Summary :

Plasma rotation can have a beneficial effect on plasma stability and confinement. For example, a strong shear in the plasma rotation is widely believed to be a key factor for turbulence suppression and the formation of transport barriers (related to plasma regimes with improved energy properties), which are considered as possible candidates for fusion reactor operation regimes in a non inductive current drive state. In present day devices, strong plasma rotation is mainly driven by Neutral Beams Injection (NBI) heating, which provides a significant external momentum source. However, in ITER and a reactor, NBI is nor expected to provide much external momentum (partly due to the high injection energy required). Consequently, it is of interest to consider other mechanisms leading to plasma rotation, as those underlying the intriguing so-called “intrinsic” plasma rotation (that is to say, with no or little external torque) reported by several tokamak experiments, e.g. in JET, Alcator C-Mod and Tore Supra. In view of the fact that it could play an important role in ITER, understanding the mechanisms underlying intrinsic rotation has become one of the most important subject nowadays, supported by the International Tokamak Physics Activities (ITPA) organization and the European Fusion Development Agreement (EFDA) Topical Group on Transport. So far none of the proposed theoretical models have been able to explain satisfactorily the experimental observations on different machines taken as a whole. The aim of the thesis proposal is to shed more light on the relevant physics of intrinsic plasma rotation in tokamaks, through a combination of further experimental work and advances in the theoretical understanding.

Plasma rotation can be understood as resulting from a competition between several mechanisms, as turbulent transport processes, fast particle effects, MHD effects, non axisymmetric magnetic field (B) effects, etc…We will focus here on fast particle effect in the presence of non axisymmetric B effect. A large number of data have been collected those past few years on Tore Supra, and additional experiment will be performed in 2012-2013. As a first step, Lower Hybrid Current Drive (LHCD) plasma regime (electron only heating scheme, generating fast electrons) will be investigated in detail. The contribution of fast electron losses on Tore Supra will be investigated using existing modelling tools (LUKE), for which the fast electron induced torque will have to be implemented. Further investigation and extension of an existing database on rotation velocity in Ion Cyclotronic Range Frequency (ICRF) heated plasmas (ion and electron heating scheme, generating fast ions) should then be undertaken. Rotation in ICRF heated plasmas is particularly interesting to study since there are similarities with a reactor plasma: low external momentum input, and a strong presence of fast particles (alpha particles in a reactor and ICRF accelerated ions in today’s tokamaks). In such plasmas intriguing observations of intrinsic rotation scaling with improved energy confinement are of particular interest. The effect of fast ion losses (mainly ripple induced) on rotation will be investigated in detail. In particular, dedicated experiments aiming at varying the fast particle fraction will be analyzed. The results will be compared with existing theories using existing modelling tools (SPOT, EVE, ASCOT, …). Finally, the experimental and theoretical work will be likely extended to other tokamaks (e.g. C-Mod, JET,…) for inter-machine comparisons. In particular, a collaboration work with C-Mod (MIT, USA) will start in 2012.

Skills : plasma physics; scientific programming