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PhD PROPOSAL 2009

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Title : Characterization of intrinsic plasma rotation in tokamaks with no external torque

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.

As a first step, Lower Hybrid Current Drive (LHCD) plasma regime (electron only heating scheme, generating fast electrons) will be investigated in detail, which has never been performed before. A database on plasma rotation will be established using existing data on Tore Supra and JET, to be completed with up-coming experiments. The contribution of fast electron losses on Tore Supra will be investigated using existing modelling tools. 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 using H-minority and He^3-minority resonant species absorbing the ICRF power are foreseen, the aim of these is to vary the fast particle fraction. The experimental results will be assessed in the light of existing theories. The coupling between rotation velocity and plasma turbulence phenomena will be studied (through density fluctuation measurement analyses). As a baseline, rotation velocity data analyses will include a prior familiarisation with the Charge eXchange Recombination Spectroscopy (CXRS) diagnostic and associated analysis tool, the CXRS diagnostic being the main diagnostic providing local measurements of plasma rotation velocity in Tore Supra. Finally, the experimental and theoretical work will be likely extended to other tokamaks (e.g. JET, TCV, ASDEX, DIII-D, JT60-U, …) for inter-machine comparisons.

Skills : plasma physics and spectroscopy; possibly scientific programming