Magnetic fusion concept and diagnostics

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After more than fifty research years on different implementations, the concept of the tokamak is a very good candidate to lead to a fusion reactor. In fact, certain regimes of functioning allow today the tokamaks to attain performances close to those requested by a reactor. Among the various scenarios of functioning nowadays considered for the reactor option, certain named 'advanced scenarios' [1] are characterized by an improvement of the stability and confinement in the plasma core, as well as by a modification of the current profile, notably thank to an auto-generated 'bootstrap' current [2]. One of the methods to achieve advanced scenarios consists of generating internal transport barriers [3]: it is about regions where a local reduction of turbulence induces a reduction of particles and heat transport. These regimes prove to be very attractive in perspective of a fusion reactor but they remain the time being transitional and often haphazard.

Numerous studies have shown the key role played by the safety factor profile in the triggering of the transport barriers [4], [5]. When barriers become too strong, gradient and peak of pressure can exceed a stability threshold, which can lead to a loss of regime. This is the reason why it is important to control in real-time both safety factor and pressure profiles to maintain a stationary barrier. Linked algorithms will be briefly introduced and discussed while application to several tokamaks will be shown. We shall see in particular that the temperature and the current profile evolve on different time scale [6]. This will drive to the notion of two time scales controller [7].

Continuous tokamak operation regime requires numerous technical developments, particularly from the point of view of the diagnostics which must be adapted to real time applications. This paper will also describe, on concrete examples, some tokamak diagnostics and their relative implication on the identification of plasma models, from which the control algorithms are constructed. To conclude, latest information about the future tokamak ITER [8] will be given.

References

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