Contribution ID: **159**

Type: **Oral presentation**

Polarized Fuel for Controlled Thermonuclear Fusion

Wednesday, 28 September 2016 10:30 (15 minutes)

The use of polarized nuclei as a fuel for thermonuclear fusion reactors was suggested more than 30 years ago and discussed in detail in a series of seminal papers [1-4]. For magnetic confinement as well as for inertial fusion the total cross section can be increased significantly. Especially for the dominant nuclear fusion reactions 2H + 3H ⟶4He+n + 17.58 MeV and 2H +3He⟶4He+p + 18.34 MeV, an enhancement factor close to 1.5 is expected in the energy range below 100 keV. Furthermore, the use of polarized fuel allows one to control the ejectile trajectories, via an enhancement in the forward-backward cross section asymmetry due to polarization. This allows one to control the energy transfer from the plasma to the reactor wall or to concentrate the neutron flux to defined wall areas.

Nevertheless, this idea was received with some skepticism by the relevant scientific community, due to some uncertainty in the physics of the process, the low efficiency in the production of polarized beams for injection into plasma and the apparent difficulty of preserving the ion polarization for a time long compared with nuclear burning time. But more recently, as a consequence of significant progress in the field of atomic beam sources and polarized targets, the interest in this matter has been refreshed for both inertially and magnetically confined plasmas.

The possibility of implementing nuclear polarization in present and future fusion reactors is discussed in this paper, with special reference to the IGNITOR project, which is currently carried on by a Italian-Russian collaboration. In particular the interaction between polarized ions and magnetic fields, both static and RF, which are typically used in a Tokamak for plasma heating via ion cyclotron resonance (ICRH), is considered.

References

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Session Classification: S4.1: Charged Beams Shaping