Challenges in Burning Plasma Physics

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Magnetic confinement fusion is approaching the era of burning plasma research, most visibly highlighted by the progress towards First Plasma being made by the ITER Project [1]. This will open an exciting new phase of magnetic fusion research, not only paving the way towards the realization of fusion energy production, but allowing the detailed exploration of plasmas in which the key physics processes determining the global plasma behaviour are driven by the α-particles produced in fusion reactions, e.g. via internal heating or their impact on MHD stability. A detailed understanding of these high temperature, collisionless plasmas and of the challenges associated with the sustainment of quasi-stationary operation in the burning plasma regime must integrate the role of turbulent transport processes, MHD stability, the interaction of high energy particles produced by fusion reactions with the thermal 'background' plasma, and the influence of 'boundary conditions' produced by interactions between the plasma and the material surfaces of the confinement vessel.

Preparation for the production of burning plasmas in ITER has been the subject of intense research in recent decades. The wide-ranging results produced by this programme have informed the development of the ITER Research Plan (IRP) [2], which analyzes the challenges to be addressed in developing burning plasmas in ITER and describes the experimental programme towards the production and exploitation of high fusion gain plasmas. Key challenges identified include sustaining the conditions for access to high confinement regimes, the need for active control of MHD stability, in particular to avoid and/or mitigate disruptions, maintenance of acceptable power and particle exhaust conditions, and achievement of reliable (fully non-inductive) steady-state operation of plasmas. The presentation will address the challenges identified via the IRP analysis and discuss the opportunities for novel physics which can be anticipated from studies of the burning plasma regime.

[1] B. Bigot, *'Progress towards ITER's First Plasma*, paper OV/1-2, Proc. 27th IAEA Fusion Energy Conf., Gandhinagar, 2018.

[2] ITER Organization, '*ITER Research Plan within the Staged Approach (Level III - Provisional Version)*,' *Technical Reports,* Vols. ITR-18-003 (https://www.iter.org/technical-reports), 2018.