Role of Energetic Ions in the ITER Research Plan

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Energetic ions play a fundamental role in the successful harnessing of magnetically confined fusion as a viable energy source for the future. Their primary role is to heat the fuel ions to temperatures at which the fusion reaction rate is sufficient to achieve a self-sustaining energy-liberating process. However, they also play important roles in reaching steady-state conditions to support this goal, requiring careful distribution in space and velocity to avoid transferring their energy to detrimental processes. Examples of these include the destabilisation of instabilities that can eject fast ions out of the plasma (although possibly beneficial for the prevention of He ash build-up). This would reduce the time available for heating the fuel ions and may require that future power plant walls are designed to cope with such fast ion losses.

The route to high fusion gain, and ultimately ignition, is essentially one of a transition from an energetic particle population determined by the external heating sources used, to one in which fusion-born alpha particles are the principal energetic ion species. The journey starts in the Pre-Fusion Power Operation phases where the energetic ion population is tailored using the heating systems to deliver the optimum current profile for the achievement of high fusion gain later in the Fusion Power Operation phase. Recent work on adapting physics models to use a commonly agreed data model has enabled the creation of sophisticated workflows integrating a hierarchy of different models and capable of describing the heating and current drive processes as well as the stability challenges of the new self-organised burning plasma regime. The creation of diagnostic models supports not only the validation of the physics models but also the development of control strategies, including optimisations arising from multiple constraints such as ELM control using 3-D fields together with tolerable wall loads. Such models can also inform the design optimisations of diagnostics still under development.

This presentation will describe the salient aspects of energetic particle physics in the various phases of the ITER Research Plan towards the achievement of ITER's mission goals.