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Frontiers in energetic particle research in fusion

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The area of energetic particle (EP) physics in fusion research has been actively studied in recent decades. Significant progress has been recently reviewed in preparations for burning plasmas (BP) [1]. This talk highlights several high priority topics to be addressed in the near future in view of broadening the active fusion studies by the Asia-Pacific researches.

The first topic remains to be important and critical for achieving the burning fusion conditions. It is on the predictions of EP transport in the presence of Alfvén Eigenmodes (AE) driven by superthermal, super-Alfvénic fast ions. In present devices AEs are observed in steady state or chirping frequency regimes driven by the confined energetic ions. Their profiles are characterized by the critical pressure gradients which in their turn are determined predominantly by the background thermal plasma dampings. Relatively simple reduced models as well as sophisticated initial value codes are developed now to uncover the underlying physics behind the relaxation of the fast ion distributions.

Another priority topic we cover is the high frequency cyclotron instabilities responsible for Ion Cyclotron Emission (ICE) [2]. Intensively studied in the past this topic is again of special interest for future BP experiments where heavy neutron and gamma radiations make it difficult in general for diagnostics to operate. At the same time measuring the magnetic field oscillations at the plasma edge is a relatively simple task but can be a powerful diagnostic tool for fusion products. In particular in JET experiments it was shown that ICE power signal is proportional to the neutron flux intensity which makes the case for ICE to be used as a diagnostic. This topic needs a breakthrough in order to be a viable tool for fusion research.

Finally we are covering the mechanisms when EP driven high frequency Alfvénic modes in ST devices lead to effective thermal electron transport as previously reported. Several ideas are considered such as the stochastic motion of thermal electrons in the presence of high frequency modes as well as the direct beam power channeling via the resonant excitation of the kinetic shear Alfvén waves. Theoretical estimates suggest that these ideas are plausible mechanisms for fusion plasmas in STs [3] and maybe relevant to conventional tokamaks. The suggested topics are important and timely now in order to identify possible new directions of the research for the fusion community.

References

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[3] E. Belova, N.N. Gorelenkov, E.D. Fredrickson et al., “Coupling of Neutral-Beam-Driven Compressional Alfvén Eigenmodes to Kinetic Alfvén Waves in NSTX Tokamak and Energy Channeling”, Phys. Rev. Lett. **115** (2015) 015001