Minutes
1st Energetic Particle (EP) session of CWGM on 17 March Evening (in Japan)
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I. Candidate issues on energetic particles in stellarator/helical devices

(1) ***Discussion/suggesons for CWGM energetic parcel physics topics in stellarators: theore+cal Viewpoint (D.A. Spong)*** presented by K. Toi [NIFS]

About 2 weeks ago, NIFS persons discussed important issues related to EP in stellarators/helical devices, of which list was provided by D.A. Spong (ORNL). It was concluded at the pre-meeting that Toi introduced the list in this CWGM.

(Discussions)

The list provided by Spong includes all important and relevant issues on energetic particles for stellarator/helical devices. No additional comment was made in this session.

II. Energetic particle driven modes in stellarator/helical devices

(2) ***Alfven eigenmodes studies on LHD*** **by Kazuo Toi [NIFS]**

Magnetic configuration of LHD is 3D, but the 3D effect on TAE and EAE characters is considerably small because of large toroidal period number N=10. TAEs, GAEs and RSAEs were observed experimentally. HAEs of which gap are formed only in 3D configuration were also observed on LHD. Nonlinear interaction between these modes and energetic ions are being investigated intensively.

(3) ***Alfvén eigenmodes measured in the TJ-II stellarator*** **by E. Ascasibar[CIEMAT]**

Radial structure of AEs has been derived by cross-correlation analysis between MP and HIBP data. The fluctuations of density and poloidal electric field induced by AEs were measured by HIBP. From these data, AE-induced radial particle fluxes were evaluated by calculation of cross-correlation between them. So far, AEs have no obvious impact on global confinement of TJ-II plasmas.

(4) ***Energetic ion driven MHD instabilities in low shear device Heliotron J*** **by S. Yamamoto [Kyoto Univ.]**

In two low magnetic shear devices H-J and TJ-II, characteristics of AEs are investigated, where GAEs and HAEs are likely energetic ion driven AEs. In H-J, the wide range of the rotational transform scan became possible since the experimental campaign of JFY2010. Rotational transform scan experiments to identify between GAE and HAE are being carried out using H-J and TJ-II in collaboration with Kyoto University and NIFS.

(Discussions)

Comparison study of AEs among low shear devices: TJ-II, H-J and W7-AS is a good example of joint experiments or joint researches. It should be noted that the rotational transform profile may be easily modified by non-inductive current and increased beta. AE characteristics will be affected by the change.

III. Energetic ion transport and losses by TAEs and other MHD modes

(5) ***Energetic Ion losses induced by various MHD modes on LHD*** **by K. Ogawa [Nagoya Univ.]**

In LHD, energetic ion losses caused by TAEs, EPMs and resistive interchange modes (RICs) were detected by a scintillator probes. The loss by TAE increases with a power s of TAE magnetic amplitude. The power is typically 2, which is diffusive type loss. With the increase in the Shafranov shift, the s increases to 3. The losses by EPMs exhibit the loss with s>3. On the other hand, the losses by RICs increase linearly with the TAE amplitude, indicating convective loss (s=1).

(6) ***Energetic Particle Issues - Theory and Simulation*** **- by Yasushi Todo [NIFS]**

The phase space structure with an Alfvén eigenmode can be investigated on the assumption of axisymmetric equilibria having the same rotational transform profile of LHD, where TAE mode structure calculated by AE3D was employed. If the TAE magnetic field amplitude at the mode center is assumed to be $\delta b/B \sim 10^{-3}$, TAE burst can transport energetic

ions radially by about a/10 (a: averaged minor plasma radius). A reduced simulation showed temporal modulation of beam ion content, although the burst time interval ~2ms is shorter than the experimental value ~10ms. This may depend on beam injection profile, pitch angle scattering, loss condition, and so on.

Code benchmarking between MEGA and AE3D-K code was done on TAE growth rates in an LHD type plasma, and showed good agreement each other.

(Discussions)

AE induced energetic ion transport and loss will be an important candidate for comparison among various stellarator/helical devices.

IV. Confinement of energetic beam ions

(7) *Experimental Evaluation of Fast-ion confinement through fast-neutral measurement with NB-blip experiments* by Masaki Osakabe [NIFS]

In LHD, beam ion confinement in a plasma without obvious energetic ion driven modes was evaluated by an NBI blip technique. Temporal change of charge exchange neutral flux associated with a blip was measured. The decay time of the charge exchange flux after a certain time delay from the NBI blip was thought to correspond to the confinement time of energetic beam ions in the plasma core. Thus derived beam ion confinement time is longer in the inward-shifted configuration than in outward-shifted one. NBI blip technique will be a useful technique in other stellarator/helical devices to evaluate energetic ion confinement.

(8) Re-entering effects on fast ion distribution function in low collisional LHD plasmas
by Ryosuke Seki [NIFS]

Particle orbits were analyzed in real coordinate of LHD. In this analysis, re-entering particles were paid attention. This effect is particularly important for outward-shifted configurations.

V. Discussions

1. Joint experiments or joint researches:

Comparison studies of AE characteristics among shearless stellarators: TJ-II, H-J and W7-AS are interesting and important. Moreover, the comparison study expands to LHD. Careful adjustment of characteristic parameters of each plasmas is necessary for meaningful comparisons.

NBI blip method is thought to be a useful technique to access energetic ion confinement. In TJ-II, NBI blip operation is not possible so far. In future, it may be applied to TJ-II and

H-J plasmas.

2. AE database

What relation does AE database has the existing MHD database? These databases do not necessarily overlap each other. An AE database may be used for code validation. For the AE database, reliable MHD equilibrium data are essential for AE analysis. In particular, the rotational transform profile is important to calculate shear Alfven spectra and eigenfunctions. Data selection and evaluations are important before registration. More discussions between AE members and MHD database contact persons are needed.

3. Code benchmarking, Validation

Code benchmark was successfully done on TAE growth rate in an LHD plasma between MEGA (Todo) and AE3D (Spong). So far, there is no information on present status of code benchmarking among several codes.

4. Alpha physics in stellarator/helical devices

Alpha confinement issue is indispensable toward stellarator/helical reactors. For instance, whether or not is high density and low temperature scenario to minimize slowing down time a favorable way? In the past meeting, configuration optimization was discussed from point of view of alpha confinement. This may not be suitable for CWGM, because it will be more reactor relevant. Nevertheless, alpha particle issue is very important and relevant for CWGM.