Recent Experiments on HL-2A Tokamak

Xuru Duan and HL-2A team
Southwestern Institute of Physics, Chengdu, China

Recent experimental campaigns on HL-2A have been focused on studying and understanding the physics of H-mode [1], zonal flow [2] and turbulence, transport [3], energetic particle [4], MHD activities and fueling. The ELMy H-mode operation has been realized on HL-2A with ECRH and NBI. Significant progresses have been achieved by substantial improvement and upgrade of the hardware. This talk focuses on the Preliminary results of ELMy H-mode experiments, experimental investigation of zonal flow, turbulence and energetic particles.

**H-mode experiments:** Typical ELMy H-mode discharges have been achieved on the HL-2A tokamak with combined auxiliary heating of NBI and ECRH (Fig. 1). The minimum power required is about 1.1 MW at the density of $1.6 \times 10^{19}$ m$^{-3}$ and increases with density decreasing. The energy loss by each ELM burst is estimated to be up to 12% of the total stored energy. The ELMy frequency is from a few ten Hz to a few hundred Hz. At a frequency typically 400 Hz, the energy confinement time is only marginally reduced by the ELMs. The supersonic molecular beam injection (SMBI) is found to be beneficial for triggering L-H transition due to less induced recycling and higher fuelling efficiency.

**Zonal Flows and Turbulence:** On HL-2A the spectral characteristics of LFZFs and GAMs were studied at the edge plasma with ECRH, and compared with those in Ohmic plasmas. The intensity of LFZFs and GAMs were observed to increase with ECRH power, and the dependence of the LFZFs and GAMs power on the safety factor were obtained. Their radial profiles and propagation were also analyzed.

**Energetic particle dynamics and MHD activities:** New features of electron fishbone (e-fishbone), including frequency up- and down-chirping, V-shape sweeping and frequency jumps, have been observed when $P_{\text{ECRH}}>0.7$ MW. The beta Alfvén eigenmodes (BAEs) excited by energetic electrons during ECRH are investigated for the first time, whose frequencies (10-30 kHz) are proportional to average energetic electron beta. But the BAEs excited by magnetic islands has mode numbers of $m/n=2/1$ and $-2/-1$, which propagate poloidally and toroidally in opposite directions, and form standing-wave structures in the island rest frame.
In the near future, the auxiliary heating and diagnostic system will be upgraded. Another 2 MW ECRH system and 2 MW NBI system, some new diagnostics such as MSE and ECEI are under development. These upgrades will enhance the capability of HL-2A for fusion physics studies.

References