First Observation of Persistent Small Magnetic Islands on HL-2A

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The threshold for the onset of neoclassical tearing modes (NTMs) is an important issue for ITER. It is well known that NTMs appearing in tokamaks are often triggered by sawteeth or edge localized modes. This phenomenon agrees with previous theories that the ion polarization current may stabilize small magnetic islands, and therefore a sufficient large seed island is required to trigger the NTMs. In HL-2A tokamak experiments, however, spontaneous and persistent small islands have been observed in most of discharges and then sometimes lead to an NTM, which challenges the existent theoretical model for the threshold for NTMs' onset, allowing a further investigation on the seed island mechanism.

The small MHD activities can exist for the whole discharge period and keep constant amplitude and frequency if the plasma parameters, such as electron density and temperature, do not change, indicating that the island is saturated. The typical parameter waveforms in an Ohmic discharge are shown in Fig.1. Two MHD modes, m/n = 2/1, 3/1 and their harmonics, are detected. The amplitude of the small MHD perturbation is $\frac{\theta B_o}{B_o} \approx 0.03 \sim 0.08 \%$. The corresponding normalized island width, $W/a$, is estimated to be a few percent. This is very different from the usual TM/NTM observed on HL-2A (see Fig. 3), which saturates at a much larger amplitude with $W/a = 0.1 \sim 0.2$.

The mode frequency of the small island is affected by plasma parameters. The relations between the mode frequency and the central plasma parameters (measured by ECE and HCN interferometer) are shown in Fig.2. The frequency of the 2/1 mode increases with increasing density and decreasing temperature.

![Figure 1. Typical parameter waveforms from the top down are, the plasma current, electron density (by HCN interferometer), electron temperature (by ECE), Mirnov signal and the spectrogram of Mirnov signal, respectively.](image)