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Toroidal Alfven Eigenmodes during Minor Disruptions in Ohmic Plasmas

Yi Tan[1], Yangqing Liu[1], Zhe Gao[1], Yuhong Xu[2], Youjun Hu[3], Rui Ke[1], Heng Zhong[1], Wenbin Liu[1], and Wenhao Wang[1]

[1] AAPPS-DPP, Department of Engineering Physics, Tsinghua University, China

[2] AAPPS-DPP, Southwest Jiaotong University, China

[3] AAPPS-DPP, Institute of Plasma Physics, Chinese Academy of Sciences, China

The experimental observation and verification of TAEs during minor disruptions with runaway plateau in ohmic plasmas of the SUNIST spherical tokamak are presented. SUNIST is a small spherical tokamak (ST) with major radius R = 0.3 m and minor radius a = 0.23 m. The experiments discussed here were performed in ohmic plasmas with plasma current $I_P \sim 40$ kA, toroidal magnetic field $B_T = 0.15$ T. The line-averaged density measured by a 94 GHz microwave interferometer was in the range of 0.2 - 6×10^{18} m^{-3}. The hard-x-ray detected by cadmium-zinc-telluride (CdZnTe) was used to estimate the energy of REs. A plastic scintillator probe was inserted into the vacuum vessel in order to directly measure the REs.

Owing to the ST configuration, ohmic discharges of SUNIST are seldom terminated by one major disruption. The plasma current often decreases in a stepwise form caused by a sequence of minor disruptions. High-frequency magnetic fluctuations have been observed during the minor disruptions from the signals detected by an array of high-frequency magnetic probes sampled at 15 MS/s. A kind of high frequency MHD modes occur during each minor disruptions which all have significant runaway plateaus. The frequency range of these modes are 150-400 kHz. Their toroidal and poloidal mode numbers are $n = -1$ and $-4 \le m \le -3$, respectively. The mode structure analysis indicates the co-existence of $m/n = -3/-1$ and $-4/-1$ harmonics, propagating toroidally opposite to the direction of plasma current and poloidally in the electron diamagnetic drift direction in the laboratory frame of reference.

There are several minor disruptions in one discharge. It can be found that the mode frequency is higher at low density and vice versa, suggesting that the modes may be Alfv´en-type modes. In order to verify it, a statistical analysis with about 200 shots was made. The observed mode frequency scales linearly with the TAE frequency $f_{TAE} = v_A/4\pi qR$, where $v_A = B_T(\mu_0\rho)^{-1/2}$ is the Alfven velocity, ρ is the mass density, q is the safety factor and R is the major radius. In the calculations, the line-averaged density and the on-axis toroidal field are used to estimate the Alfven velocity. The safety factor is estimated by mode numbers. Therefore, these high frequency MHD modes should be TAEs. The measured edge magnetic fluctuation level of the TAE is about one gauss, and $\delta B_\theta/B_T \sim 2 \times 10^{-3}$. Moreover, the signals measured on outboard coils are generally stronger than those measured on inboard coils suggesting that the TAE exhibits a ballooning feature.

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