

Electron Bernstein Wave Studies in MAST

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Burning plasma spherical tokamak (ST) designs rely on off-axis current drive and non-solenoid start-up techniques. Conventional ECRH and ECCD methods typically cannot be used in STs because of the specific plasma parameters. Usually the plasma is well overdense in STs, i.e. ($\omega_{pe} \gg \omega_{ce}$) where ω_{ce} and ω_{pe} are the electron cyclotron and plasma frequencies. In such plasmas the first few EC harmonics in the core plasma are completely obscured by the O and X mode cutoffs. In contrast, electron Bernstein waves (EBWs) can propagate in overdense plasma and may provide efficient off-axis heating and current drive (CD) in high density ST plasmas. EBW may also be used in the plasma start-up phase due to the fact that EBW absorption and CD efficiency remain high even in relatively cold plasmas. EBWs can be excited within the plasma with the externally launched X or O modes via mode conversion mechanisms. There is a comprehensive, closely-interlinked EBW programme on MAST covering heating experiments, plasma start-up studies, plasma emission measurements, theory and modelling.

Proof-of-principle EBW heating experiments (60 GHz, 1 MW) have been conducted on MAST. Clear evidence for the ordinary-extraordinary-Bernstein (O-X-B) mode conversion and subsequent heating has been observed for the first time in an ST [1].

A major advance in the integrated modelling of EBW, involving a suite of codes, has been achieved. The EBW excitation in the plasma is first considered as a full wave 1D mode-coupling problem. Then propagation of the EBW is computed using an EBW ray-tracing code. The ray tracing data are then used in a relativistic 3D Fokker-Planck code to calculate the heating and driven current profiles.

Extensive EBW emission measurements in the frequency range 16-67 GHz covering the first 6 EC harmonics provide an important insight into the mode coupling physics. A fast spinning mirror has been installed recently at the front of the receiving antenna of the frequency scanning EBW radiometer. This will allow real time measurements of mode conversion dynamics during plasma evolution. This is also a potential q-profile diagnostic at the plasma edge.

The 28 GHz EBW start-up system has been installed on MAST [2]. The gyrotron is capable of delivering up to 200 kW for 40 ms. Plasma breakdown has been achieved at the fundamental EC resonance with both the O-mode launch and the X-mode launch. Plasma currents up to 15 kA were observed during RF breakdown phase with the O-mode (100 kW) launch in the presence of toroidal field and weak (~5 mT) vertical magnetic field. First experimental and plasma modelling results will be presented and discussed.

[1] V. Shevchenko et al., Proc. 14th Joint Workshop on ECE and ECRH, Santorini, Greece, 54 (2006).

[2] V. Shevchenko et al., Proc. 13th Joint Workshop on ECE and ECRH, Nizhny Novgorod, Russia, 255 (2004).

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