Characteristics of quiescent H-mode plasmas with co-, ctr- and balanced injection of neutral beam in JT-60U

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The quiescent H-mode (QH-mode) is one of the alternative H-mode regimes in a low collisionality region, which has the possibility to solve the instantaneous heat and particle loads on the divertor by ELMs. The characteristic MHD activity in QH-mode plasmas is the edge harmonic oscillations (EHOs), which is usually observed instead of ELMs. The edge Er well in QH-mode is significant deeper than that in standard H-mode [1]. Although one of the key requirements for producing the QH-mode is ctr-NB injection in other devices, QH-mode with co-injection is also observed in JT-60U [2].

JT-60U has eleven beam units for positive ion based NBI. Seven units are nearly perpendicular to the plasma current and the other four units consist of two co-tangential and two counter-tangential NBs. Various combinations of these NBs make it possible to scan the toroidal rotation velocity profile. By utilizing this capability of NB system, the influence of NB combination on production of QH-mode can be investigated during a discharge. The QH-mode was observed in co-, ctr- and balanced injected plasmas with large and optimum outer mid-plane gap between the separatrix and the first wall on the low field side. The EHOs were observed in the edge channels of the ECE and BES diagnostics during QH-mode phases. The high-n ballooning stability analysis using equilibrium accurately reconstructed using the EFIT code with kinetic profile shows that the plasma during ELMy phase with co-injection appears to sit a lot closer to the edge stability boundary than the QH phases with co-, ctr- and balance injections, probably due to the difference in the edge pressure gradient and edge current density. All four equilibria are stable to intermediate-n peeling-ballooning modes. Larger edge pressure gradient and less edge current appeared in ELMy phase than QH-mode phase. Furthermore the edge Er profiles were evaluated based on CXRS measurement during the QH-mode and during ELMy phase in co-injected discharges. In both cases, the contribution of poloidal rotation term is dominant and the edge Er well just before the ELM is slightly larger than during QH-mode.

[1] K. Burrell et al., Plasma Phys. control. Fusion 46 (2004) A165.
[2] N. Oyama et al., Nucl. Fusion 45 (2005) 871.