

Modification of sawtooth oscillations with ICRF waves in the JET tokamakM.J. Mantsinen^{1,2} and JET-EFDA Contributors*¹*Max Planck Institute for Plasma Physics, EURATOM Association, Garching, Germany*²*Helsinki University of Technology, Association Euratom-Tekes, Finland***See Appendix of M.L. Watkins et al., Fusion Energy 2006 (Proc. 21st Int. Conf. Chengdu, 2006) IAEA, (2006).*

The sawtooth instability, giving rise to repetitive redistribution of the central part of a tokamak plasma when the central safety factor is below one, plays a number of key roles in tokamaks. Sawteeth are well known to remove impurities from the plasma core, which could find important applications in helium ash removal in a future fusion reactor based on deuterium-tritium fuel. Long period, i.e. stabilized, sawteeth give rise to centrally-peaked density and temperature profiles, which can have a positive effect of increasing the attainable fusion power. It is well established that high-energy ions, such as 3.5 MeV alpha particles (⁴He ions) born in deuterium-tritium fusion reactions, can have such a stabilizing effect on sawteeth. Unfortunately, subsequent sawtooth crashes have been associated with triggering neoclassical tearing modes (NTMs). Unless these modes can be avoided or stabilised, they could significantly limit the attainable fusion performance. One of the ways to achieve this is to shorten the sawtooth period, i.e. destabilise the sawteeth, so that seed islands for NTMs are not triggered in the first place. This has been the main motivation behind the recent development of sawtooth control techniques using RF waves.

The present paper reviews the achievements in modifying the sawtooth period and amplitude on the JET tokamak, using waves in the ion cyclotron range of frequencies (ICRF). Classical examples of sawtooth stabilization by ICRF-accelerated high-energy ions together with the theoretical explanation are presented. In experiments with ICRF-acceleration of ⁴He-beam ions to simulate the effects of fusion born alpha particles, sawtooth stabilization due to these ‘artificial’ alphas leads to triggering of NTMs. When high power ICRF heating is applied in low-density plasmas, fast ion stabilization of sawteeth is lost and a new type of small-period and small-amplitude sawteeth, referred to as “grassy” sawteeth, appears. ICRF-induced radial pinch with toroidally asymmetric waves and the use of multiple ICRF frequencies are found to be useful tools in affecting ICRF-driven fast ion populations and thereby their stabilizing influence on the sawteeth. Ion cyclotron current drive (ICCD) applied close to the sawtooth inversion radius has been found effective in modifying the sawtooth period both at the fundamental and second harmonic ion cyclotron frequency. The latest achievements include the successful application of ICCD to shorten the fast-ion-induced long-period sawteeth and thereby avoid triggering of NTMs.