L-H transition studies in hydrogen and mixed ion species plasmas in JET


EUROfusion Consortium JET, Culham Science Centre, Abingdon, OX14 3DB, UK
1CCFE, Culham Science Centre, Abingdon, Oxon, OX14 3DB, UK, 2Oak Ridge National Laboratory, Oak Ridge, Tennessee, USA, 3Laboratorio Nacional de Fusion, CIEMAT, Madrid, Spain, 4Instituto de Plasmas e Fusão Nuclear, Instituto Superior Técnico, Universidade de Lisboa, Lisboa, Portugal, 5Laboratory for Plasma Physics Koninklijke Militaire School - Ecole Royale Militaire, Brussels, Belgium, 6Aalto University, Aalto, Finland, 7Max-Planck-Institut für Plasmaphysik, Garching, Germany, 8Barcelona Supercomputing Center, Barcelona, Spain, 9ICREA, Barcelona, Spain, 10Chalmers University of Technology, Göteborg, Sweden, 11EUROfusion PMU, Abingdon, UK

The L-H transition has been studied in JET -- with an ITER-like W/Be wall -- in hydrogen, mixed hydrogen-deuterium, and mixed hydrogen-helium plasmas. Experiments in JET-ILW find there is a strong dependence on heating method: while for plasmas using only ion cyclotron resonance heating $P_{L-H}$ increases about a factor of two from deuterium to hydrogen plasmas, the difference can be a factor of three or more for plasmas heated only with co-Ip neutral beam injection. This dependence of $P_{L-H}$ on heating method is notably different than studies of confinement in ELMy H-modes in JET [1], which found no significant dependence on the mix of NBI and ICRH heating. Calculations of power deposition show that in the NBI-heated plasmas, the power going to ions and electrons is comparable, while in the ICRH-heated plasmas, which used 2nd harmonic hydrogen heating, most of the power is absorbed by the ions. Results from transport analysis of heat fluxes through the separatrix will be presented, and compared to previous results implicating either a role for rotation [2] or the ion heat flux [3] to resolve the large dependence on heating method. Experiments have also been performed in hydrogen-deuterium and hydrogen-helium mixtures. The dependence of $P_{L-H}$ on mixture ratio is non-linear, with most change observed at small concentration ratios $n_H/n_{H+D}<0.2$ or $>0.8$, while little change is observed over a broad intermediate range between 20% and 80%. Similar behavior is observed in experiments using up to 8% helium seeding in hydrogen plasmas, which could have implications for the non-active phase of ITER operations. Due to different ion masses, the energy exchange with electrons is necessarily different between the two ion species. This potentially introduces an additional time scale, for energy equilibration between the ion species; since that collisional exchange rate depends on the product of the ion densities, it could explain the strong dependence at small concentrations. The impact of heating deposition, energy exchange, and energy transport channels will be assessed for the mixed ion species plasmas as well.

This work is carried out within the framework of the EUROfusion Consortium and receives funding from the Euratom research and training programme 2014-2018 under grant agreement No 633053 and from the RCUK Energy Programme grant No EP/I501045.

References:

*See the author list of "Overview of the JET results in support to ITER" by X. Litaudon et al. to be published in Nuclear Fusion Special issue: overview and summary reports from the 26th Fusion Energy Conference (Kyoto, Japan, 17-22 October 2016)