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Predictive dynamics of tearing modes for plasma stability in DT and TT scenarios considering JET Baseline and Hybrid discharges with mixture of isotopes

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Studies of the effects of hydrogen (H) isotopes are an important issue on achievement of high performance in the next Deuterium–Tritium (DT) and Tritium-Tritium (TT) high beta operations at JET with ITER-like Wall. Experiments with mixed H-D plasmas have been recently performed at JET to understand the dependence of the confinement on these isotopes by varying the gas, beam [1] and pellet fuelling [2]. Since strong dependence on confinement has been found in mixed plasmas close to pure values of H or D and no dependence for other values of the isotope mixture, while opposite behavior is expected for any DT composition, magnetohydrodynamic (MHD) instabilities could still play a key role in the confinement loss. Particularly, the Neoclassical Tearing Modes (NTMs), observed in Baseline and Hybrid scenarios, are responsible for a decrease of performances leading in some cases to disruptions. In JET plasmas most detections of NTMs at low poloidal (m≤5) and toroidal (n≤4) mode numbers have been observed for betaN< 2.2 in Baseline and for betaN>2 in Hybrid [3]. Predictions of effects of different isotope mixtures on NTMs onset and dynamics can provide indications for the plasma stability, with modes appearance depending on the isotope ion mass mi . In fact the modelling of the width evolution, integrated in the European Transport Simulator (ETS) [4], is described by a a generalized Rutherford equation –GRE–[5] where the bootstrap and the ion polarization terms contain the mi dependence through the ion collision frequency and the ion Larmor radius. Simulations of HD and DT plasmas, extrapolated from high power and neutron rate discharges, have been provided taking into account physics aspect as transport, turbulence and energetic particles [6].
Isotope action on MHD instability is now considered as well. First predictions of the favourable NTMs onset allowed by high bootstrap current (Jbs) have been provided considering the JET baseline pulse #92436 (2.8T, 3MA, 28 MW NBI, 6 MM ICRH). The aim was the evaluation of Jbs considering different fraction of the H-D-T isotopes in the same scenario neglecting other isotopes effects in the plasma core and edge. In this case, considering the total pressure as the sum of different fraction of isotopes with same gradients for the ion density profiles, the bootstrap current changes are negligible (£1%) [7] for all H-D-T ratio as shown in figure 1, where Jbs from the transport models NCLASS [8] and NEOS [7], integrated in ETS, were compared. The goal of this paper is to predict the tearing onset and evolution in DT and TT baseline and hybrid scenarios provided by ETS where transport simulations take into account different physics aspects and also the change of electron, ion and
heavy impurities perpendicular diffusion coefficients due to the presence of NTM [9].

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As many discharges with and without NTM and with the same betaN are in the JET database, a plasma stability range will be given in this paper as function of poloidal beta in order to determine the pressure and shear conditions for the mode avoidance in DD and DT plasmas.
Isotopes affect also the duration of the sawtooth (ST) period very important for the NTMs destabilization.
These modes can be triggered by a crash of a ST period when the magnetic shear becomes larger than a crtical one (s1,cr) proportional to the ion mass normalized to the proton mass as (mi/mp)1/3. It means that for the same q profiles the ST periods in H are smaller than the ones

in D, because s1,cr(H) < s1,cr(D) , as observed in isotope identity experiments [10] and shown in figure 2. Here, the sawtooth periods in H are about 80-90 ms, while in D about 140-150 ms. As the mode onset is usually observed after a crash of a long ST period, the condition of the NTMs destabilization should be more favourable in D plasmas than in H and more in T than in D. This isotope dependence is investigated in this paper using the sawtooth model integrated in ETS [11].

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Results of the role of NTMs on plasma stability in baseline and hybrid DT and TT scenarios will be compared with JETTO-JINTRAC [12] simulations obtained in the same plasma conditions.

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