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Modelling of the current density profiles in the high β JET plasmas guided by MHD markers and kinetic data

F. Auriemma[1,6], G. Pucella[2], E. Aymerich[3], A. Bock[4], A. Burckhart[4], C. Challis[5], E. Giovannozzi[2], N. Hawkes[5], J. Lombardo[6,7], M. Poradzinsky[5,8], G. Sias[3], M. Baruzzo[2,6], D. Keeling[5], C. Piron[2,6], JET team[*], and WPTE team[**]

[1]Istituto per la Scienza e la Tecnologia dei Plasmi del CNR, Padova, Italy [2]ENEA C. R. Frascati, via E. Fermi 45, 00044 Frascati (Roma), Italy [3]Università degli studi di Cagliari, Dipartimento di ingegneria elettrica ed elettronica, Via marengo 2 Cagliari [4]Max-Planck-Institut für Plasmaphysik, Garching, Germany [5]UKAEA, Culham Campus, Abingdon, Oxfordshire, OX14 3DB, UK [6]Consorzio RFX (CNR, ENEA, INFN, Università di Padova, Acciaierie Venete SpA), Corso Stati Uniti 4, 35127 Padova, Italy [7]CRF - University of Padova, Padova, Italy [8]Institute of Plasma Physics and Laser Microfusion, Hery 23, 01-497 Warsaw, Poland, *See the author list of “Overview of T and D-T results in JET with ITER-like wall” by C.F. Maggi et al (Nuclear Fusion Special Issue).** See the author list of “Overview of the EUROfusion Tokamak Exploitation programme in support of ITER and DEMO” by E. Joffrin Nuclear Fusion 2024 10.1088/1741-4326/ad2be4

e-mail(speaker): fulvio.auriemma@igi.cnr.it

The performance of the flat-top phase within a plasma scenario is influenced by numerous factors, including the process of current ramp-up. This phase holds significant importance in determining critical parameters such as the availability of magnetic flux during the flat-top, initial impurity levels, and permissible MHD activity. Its significance is particularly emphasized in advanced/hybrid plasma scenarios, where the ramp-up phase is utilized to optimize the target q-profile. In hybrid-like plasmas, achieving a steady state q-profile involves "freezing" the natural evolution of the q-profile during the ohmic phase, subsequently reducing resistivity through additional heating. This optimization is crucial for accessing high β during primary plasma heating while minimizing the risk of MHD instabilities [Challis2020]. Consequently, modelling the ramp-up phase becomes a vital tool for supporting the development and understanding of high β scenarios. This work endeavours to integrate current evolution TRANSP modelling with data from MHD and kinetic diagnostics, aiming for a comprehensive description of the ramp-up and flat-top phases in high β JET plasmas. As already shown in the past for example at JET [Kelliher2005, Ho2023] and MAST [Keeling2018], both the classical and the neoclassical resistivity models have pros and cons in predicting the experimental current profiles evolution during the ramp-up of the plasma current. However, here we show that in dedicated ohmic pulses, both the models are unable to capture the linear dependence of the q=1 arrival time t_{q1} on the toroidal field B_t, as estimated by the MHD markers. In particular the classical model largely fails since it computes a too slow current diffusion whereas the neoclassical resistivity, besides providing results more in line with the experiments, is still associated to a faster diffusion. Actually, the neoclassical resistivity is expected to only partially describe the inner core plasma region (□<0.25), because it doesn’t include some important effects as, for example, the so called “potato orbits” [Satake2002] which have the effect of increasing the core resistivity with respect to the pure neoclassical one. In order to increase the accuracy of the core current profile reconstruction, the sensitivity scan on the amplitude and width of a plausible (given the T_e hollowness, the radiation profiles, etc.) core Gaussian-shaped effective charge profile is presented. The quality of the reconstruction is assessed, for the ramp-up phase, by comparing the numerical results with the experimental t_{q1} and the temporal evolution of the inversion radius. Moreover the flat-top analysis of the beam heated plasmas, besides the core n=1,2 MHD analysis, can exploit further diagnostics as the MSE and the Charge Exchange spectrometers, providing the quantification of the confidence interval on the current profile reconstructions. The development of an alternative resistivity model is beyond the scope of this analysis, but still it can be guided by the results shown in this work.

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