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Inclusion of opacity in collisional-radiative models of hydrogen-like He and D to explain discrepancies with line intensity measurements in the JET tokamak

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An understanding of the description of the discharge fuel, either D or He, is essential in order to model processes in the plasma edge and divertor, these processes including transport simulations of the plasma exhaust and the determination of plasma-facing surface erosion. The emission from the fuel species is described by collisional-radiative models. However, discrepancies have been found between the models and observations made in the JET tokamak. Lawson et al. (2022 and 2023a) give detailed measurements of He II (He+) Lyman series line intensities and their ratios and also make comparisons with He II Balmer and Paschen series members. A collisional-radiative model involving routinely occurring opacity is developed in order to explain the observations. Attention is given both to the equilibrium discharge phase when constant line intensity ratios indicate very similar temperatures for the plasma regions emitting the hydrogen-like radiation and exceptional phases in which the line intensity ratios deviate from these near-constant values. In particular, the variation of the electron temperature throughout discharges is illustrated. Increases in temperature during the non-equilibrium, exceptional phases are understood in terms of transient effects of recycling particles. Pulses in which additional opacity beyond that routinely occurring are investigated. Both the routinely occurring opacity and the limited temperature range of the emitting plasmas are expected to have implications for the interpretation of various analyses.

Lawson K D et al., 2022, Report 'He II Lyman series line intensity measurements in the JET tokamak'
Lawson K D et al., 2023a, Report 'He II VUV and visible line intensity measurements in the JET tokamak'
*See author list of 'Overview of JET results for optimizing ITER operation'by J Mailloux et al., 2022, Nucl. Fusion, 62, 042026

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