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Multiphysics approach to plasma neutron source modelling at the tokamak JET

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The work presented in the paper is focused on the development of a multiphysics methodology for the creation of a realistic plasma neutron source for Monte Carlo neutron transport calculations. We begin with a description of the plasma neutron sources used in fusion neutronics so far – these are based on the assumption that the plasma is in thermal equilibrium, the neutrons being emitted isotropically and their spectrum approximated with a Maxwellian distribution. The plasma shape and neutron emissivity profiles are analysed, exhibiting major discrepancies from the current JET ITER-like wall plasma state. The analysis serves as motivation for the development of a more adequate description of JET plasma neutron emission. The methodology is based on the use of the state-of-the-art plasma transport code TRANSP and the neutron spectrum computation code DRESS. The diagnostic data of a baseline DD discharge of the JET tokamak is used as input for the TRANSP/NUBEAM ion orbit code, which evaluates the beam-target fusion reactions that govern neutron production. These simulations are the basis for the evaluation of the neutron spectra, which are performed with the DRESS code. In the next step the generation of a Monte Carlo neutron source description is discussed – the data on plasma state relevant to neutron emission is processed, meaning that the probability density functions for specific quantities are computed. The script assigned for the pre-processing is designed to serve as a tool for the analysis of neutron emission, outputting both the measured and simulated neutron rates, offering insight not only into the essentials for neutronics but also discharge specific plasma physics. A subroutine based on the source code characteristics of the advanced Monte Carlo neutron transport code MCNP is described. Within the routine the prepared plasma data is used to obtain fundamental source neutron information, i.e. location of birth, angle of emission and energy. The performance of the subroutine is analyzed and found to be comparable to MCNP generic and much simpler source descriptions. The paper is concluded with a comparison of the response of several neutron detector systems at JET (KN1, KN2) as calculated with the MCNP Monte Carlo neutron transport code, using the generic and newly developed neutron source generators.

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