Component wise DT fusion yield extrapolation with neutron spectrometry

A. Sahlberg[1], C. Hellesen[1], J. Eriksson[1], S. Conroy[1],
G. Ericsson[1], L. Garzotti[2], D. King[2] and JET Contributors*
[1]*Dept. of Physics and astronomy, Uppsala University, Sweden*
[2]*CCFE, Culham Science Centre, Abingdon, Oxfordshire, UK*

As part of the preparation for ITER, a second Deuterium-Tritium campaign (DTE2) is planned at JET. To this end, methods for quickly and robustly predicting fusion yields of DT plasmas are sought. This paper investigates how neutron emission spectroscopy can predict equivalent DT fusion power of a deuterium discharge.

The energy spectrum of the emitted neutrons has three major components (thermonuclear, beam-target, RF-target) which scale differently when going from a DD to a DT plasma. For each reaction component, a DD to DT scale-up factor can be calculated as the ratio between the DT and DD reaction rates. The scale-up factors depend on the cross sections, the energy distributions of the plasma ion species as well as the assumed fuel ion ratio n_t/n_d.

From the component scale-up factors the total neutron rate scale-up factor can be calculated if the relative intensities of the neutron rate components are known. These can be estimated from the neutron energy spectrum, which is here measured with the time-of-flight spectrometer TOFOR. The component scale-up factors are calculated using an ion temperature, either measured with charge exchange recombination spectroscopy or estimated from the neutron spectrum, along with a beam-ion distribution obtained from slowing down calculations.

This method for identifying and separating the neutron reaction components and scaling them up from DD to DT has been applied to several JET pulses and compared to both earlier DT shots at JET (from the 1997 campaign DTE1) and DT extrapolations made with the transport codes JINTRAC and TRANSP. The comparisons with TRANSP fall within error bars while comparisons with JINTRAC differ by around 15-25%. The reason for this discrepancy is under investigation. Predicted DT fusion yields fall in line with comparable shots from DTE1. The current record baseline and hybrid discharges are both predicted to reach 6-7 MW of fusion power.

The above results indicate that this method is useful for making quick and robust predictions for future DT pulses.

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