Measuring RF-accelerated fast ions with DD and DT neutron spectroscopy: comparison of velocity-space sensitivity

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Two of the most important reactions in a fusion plasma are the D(d,n)^{3}He (DD) and T(d,n)^{4}He (DT) reactions. Both these reactions produce neutrons, and if a neutron spectrometer is used to resolve the emitted neutrons in energy it is therefore possible to infer various features of the energy distribution of the D and T fuel ions. Furthermore, if the neutron spectrum is measured along several different sightlines, it is possible to resolve the fuel ions spatially and/or in pitch as well. A common application of neutron spectroscopy is the study MeV-range fast ions, which typically result in distinct high-energy tails in the neutron spectrum.

The DD and DT reaction cross sections exhibit different dependences on the reactant energies. Hence, the neutron spectra of DD and DT neutrons is sensitive to different regions of the fast-ion velocity-space. In this contribution, we examine this velocity-space sensitivity in detail, by means of previously determined velocity-space weight functions. By multiplying the weight functions with various trial distributions representative of radio-frequency (RF) accelerated ions at the JET tokamak, we obtain explicit maps of how much different regions of the fast-ion velocity-space is expected to contribute to the measured neutron spectrum.

For JET-relevant distributions of RF-accelerated deuterons, we find that the average energy of fast ions contributing to the DD signal is about 50-100 percent higher than the average energies of the ions contributing to the DT signal. DD spectroscopy can therefore probe the most energetic part of an RF-accelerated ion distribution (MeV-range ions), while DT spectroscopy is mostly sensitive to more intermediate energies (200-500 keV). The implications of these results for the interpretation and comparison of recent DD and DT neutron spectroscopy results at JET is discussed.

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