Reconstraction of the energy distribution function of Fast ions in tokamak plasma by gamma-spectrometry methods

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The confinement of fast ions in plasma is one of the key issues in the formation and maintenance of controlled thermonuclear fusion. Fast ions in tokamak plasma arise due to ion-cyclotron resonant heating, injection of a beam of neutral atoms, and also as a result of thermonuclear reactions in plasma. The study of the energy distribution functions of fast ions seems to be one of the most effective ways to study the nature and behaviour of fast ions in plasma during a tokamak discharge, which is of particular value for future projects such as ITER.

Gamma spectrometry methods allow for this kind of research. Detectors based on fast scintillators in conjunction with using specially developed signal processing algorithms provide measurements of gamma-radiation spectra with sufficient time resolution and efficient separation of piled-up pulses in measurements with a high counting rate. The ITER tokamak assumes the presence of several gamma spectrometry diagnostics. One of these systems is being developed at Ioffe Institute. The gamma spectrometer will be installed in the port cell of the equatorial port #11 behind the Neutral Particle Analyzer system and will have a radial line of plasma observation. The spectrometer includes two detectors a semiconductor HPGe detector and a LaBr3(Ce) scintillation detector. This detector system will allow the study of fast ions in plasma under conditions of high neutron and gamma fluxes from the ITER plasma.

Methods of reconstruction of fast ions energy distribution in tokamak plasma are being developed at Ioffe Institute. One of the methods is based on analysing the intensities of gamma lines from nuclear reactions between the studied accelerated ions and impurities (9Be and 12C) with using information about the cross sections of nuclear reactions in the plasma.

Developed methods were tested in plasma experiments on the JET tokamak (Joint European Torus, Culham, UK). In the studied D-H plasma discharges with a 3He impurity at JET, both ICRH and NBI were used, which provided a sufficient amount of high-energy ions in the JET plasma and intensive gamma lines from the nuclear reactions to reconstruct the energy distribution of fast 3He ions. The report presents the results of the reconstraction of the fast ions energy distribution in the JET tokamak plasma.

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