Investigation of $^3$He emission in three-ion ($^3$He) D-H ICRF heating experiments*

K. T. Liao1, W. L. Rowan1, Ye.O. Kazakov2, J. Hughes3, Y. Lin3, J. Wright3, S. J. Wukitch3
1Institute for Fusion Studies, UT Austin
2Laboratory for Plasma Physics, ERM-KMS
3Plasma Sciences and Fusion Center, MIT

Introduction
Helium-3 emission excited by charge exchange with a diagnostic neutral beam was observed during a three-ion ICRF scenario. The emission was used to diagnose and control the plasma during ICRF heating experiments. The high single-pass absorption by a trace concentration of neutral helium ions heated the plasma, driven the fast ion population, and possibly drive flow. With the beam heating being the primary source of the beam-heated helium, the fast ion heating scenario excited the neutral helium ions by charge exchange with a diagnostic neutral beam. The helium density in the plasma was measured using scattering spectroscopy and Thomson scattering as a function of time. The helium density was measured using scattering spectroscopy and Thomson scattering as a function of time. The helium density was measured using scattering spectroscopy and Thomson scattering as a function of time. The helium density was measured using scattering spectroscopy and Thomson scattering as a function of time.

3 Ion Heating Scenario

3-ion heating scenario is a novel approach to the problem of heating in a hydrogen plasma using a hydrogen + helium mixture. The helium ions are heated by the ICRF power, and the resulting fast ions heat the plasma. The helium density in the plasma is measured using scattering spectroscopy and Thomson scattering as a function of time. The helium density was measured using scattering spectroscopy and Thomson scattering as a function of time. The helium density was measured using scattering spectroscopy and Thomson scattering as a function of time. The helium density was measured using scattering spectroscopy and Thomson scattering as a function of time.

Dependence on the Helium concentration

Helium density must be small enough such that fast wave propagation characteristics determine the fast wave propagation characteristics. The helium density was measured using scattering spectroscopy and Thomson scattering as a function of time. The helium density was measured using scattering spectroscopy and Thomson scattering as a function of time. The helium density was measured using scattering spectroscopy and Thomson scattering as a function of time. The helium density was measured using scattering spectroscopy and Thomson scattering as a function of time.

Experimental Plasma

The plasma was studied using a fast Fourier transform (FFT) analysis of the time traces of TOFC power and Thomson scattering measurements of beam and beam density. The plasma was studied using a fast Fourier transform (FFT) analysis of the time traces of TOFC power and Thomson scattering measurements of beam and beam density. The plasma was studied using a fast Fourier transform (FFT) analysis of the time traces of TOFC power and Thomson scattering measurements of beam and beam density. The plasma was studied using a fast Fourier transform (FFT) analysis of the time traces of TOFC power and Thomson scattering measurements of beam and beam density. The plasma was studied using a fast Fourier transform (FFT) analysis of the time traces of TOFC power and Thomson scattering measurements of beam and beam density.

Fast ion charge exchange

For a non-Maxwellian population, the charge exchange cross section is not Gaussian, but depends on the velocity distribution. For a non-Maxwellian population, the charge exchange cross section is not Gaussian, but depends on the velocity distribution. For a non-Maxwellian population, the charge exchange cross section is not Gaussian, but depends on the velocity distribution. For a non-Maxwellian population, the charge exchange cross section is not Gaussian, but depends on the velocity distribution.

Hammann proposed a fast ion velocity distribution model [104, Hammann: Ph.D. Thesis (1996)]

where $\gamma$ is the ion energy distribution function, $\gamma_a$ is a correction factor, $\gamma$ is the beam energy, $\gamma_b$ is the beam energy, $\gamma_c$ is the beam energy, and $\gamma_d$ is the beam energy.

Synthetic $^3$He charge exchange emission spectra for different intensities of wave absorbed power, based on Hammann's model for fast ions. Left shows a poloidal view, which observes perpendicular to the field. Right shows a toroidal view, which observes parallel to the field.

Table 1. Selected parameters for 6 shots from the three-ion ICRF experiment. Capacitive three-gas operation on the gas input lines serve as constant helium concentrations, but don’t take into account differences in intensity and transport of the different ions. Stored Energy increase is the increase in stored energy from the time when ICRF is started to the peak value divided by ICRF power. It is used as a rough figure of merit for heating efficiency. 1108001004 has a significantly lower electron density so cannot be directly compared.

To conclude, the three-ion ICRF heating scenario has a better regime for high efficiency ICRF heating and fast ion production.

*Author contact: kentliao@physics.utexas.edu