Simulating Low Temperature Maxwellian Plasma using SH-HtscEBIT

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Maxwell–Boltzmann distribution is commonly known in astrophysical plasma, fusion plasma and other laboratory plasmas. Emission lines of Li-like carbon ions have become one of the most useful tools for temperature and density diagnostics, since carbon is one of the most abundant elements in solar and stellar plasmas, and also is an important impurity element in tokamaks with carbon divertor [1]. In these studies, the plasma temperature is usually lower than 100 eV and a great effort in theoretical work has been done to study electron impact excitation of C IV [2].

In the respect of experimental works, an equal number of benchmark measurements of cross sections are needed to test these calculations and models. One of the well-known laboratory Maxwellian plasmas devices used for measuring electron–ion collisional rate coefficients is tokamak, by which a fair number of excitation, ionization, and recombination rate coefficients have been determined [3]. The plasma spectrum in a tokamak is often complicated for the reasons of ion species and charge state variety caused by the density and temperature gradient in space, moreover, many satellites making lines blended, leading to the limitation in accurate determination of line wavelength and intensity. By comparison, an electron beam ion trap (EBIT) has a good advantage of an energy-adjusted electron beam, a stable electromagnetic field environment and a clean plasma detective source, of which only the injected element with a fraction of background ions are trapped in the center region. However, the electron beam in an EBIT is approximately monoenergetic. In order to produce quasi-Maxwell–Boltzmann plasma, an energy sweep technique was developed [4]. The minimum and maximum temperatures are restricted by the low-energy limit and the largest energy scanning region in the EBIT. Here we present an experimental realization of Maxwellian carbon plasma with rather low electron temperature of 15 to 40 eV in the SH-HtscEBIT. Both the measurements and the theoretical calculations of C IV (n = 3 – 2) spectrums were carried out for comparison to verify the accuracy of the simulated Maxwell–Boltzmann distribution.

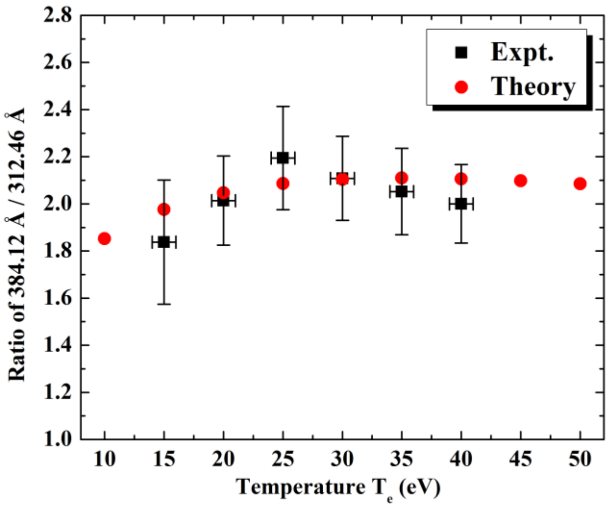

Figure 1. The measured (black square points) and modeled (red circle points) intensity ratio of C IV 384.12 Å over 312.46 Å along the simulated plasma temperature of 10 to 50 eV.

References

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