§18. Plasma Diagnostics with Fast Electrons: 2nd Maxwellian vs. Beam

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Non-Maxwellian electron energy distributions are frequently met in both astrophysical and laboratory plasmas. Though non-Maxwellian electrons account generally for a small part of the total number of electrons, the deviations from the Maxwellian distribution can nevertheless drastically change the observed emission spectrum. Mostly the effect of superthermal electrons is modeled by the second Maxwellian with a temperature larger than that of the bulk of electrons in plasma. This is probably due to the availability of a large amount of accurate data on Maxwellian averaged rates of collisional processes. However, as we show below, the use of a second Maxwellian distribution may lead to results very different from what is obtained with other shapes of fast electrons distribution function.

In our calculations we use the time-dependent plasma kinetics code developed at the Plasma Laboratory of Weizmann Institute of Science. The processes included into the current version of the code are collisional excitation, deexcitation and ionization (including multiple ionization and ionization into excited states), radiative spontaneous emission and photorecombination, dielectronic and three-body recombination. All collisional processes are presented by their cross sections which enables us to calculate the rates for arbitrary electron distribution function. Most of relevant data on electron-ion collisions were taken from the NIFS Atomic Database or calculated with the "ATOM" code by L.A.Vainshtein. Our calculations have been carried out for Neon with total of 101 terms included for all 11 charge states.

As an example, here we present line intensity ratio $\alpha \equiv Ly_{\alpha}[He]/Ly_{\alpha}[H]$ which is widely used in temperature diagnostics. The temperature of 99% of electrons in plasma T_e was taken to be 50, 200 and 500 eV while the electron density n_e was allowed to change in the range 10^{10} - 10^{20} cm^{-3}. The superthermal electrons constituting 1% of total electron density were modeled by (i) second Maxwellian with the temperature T_2 = 10 keV or (ii) rectangular electron energy distribution function (beam) with the beam center at 10 keV and full beam width of 4 keV. For each value of temperature and total electron density the line ratio α was calculated for cases (i) and (ii) (α_{2Maxw} and α_{Beam} respectively) assuming collisional-radiative equilibrium. In Fig. 1 the ratio $\alpha_{2Maxw}/\alpha_{Beam}$ is presented. One can see that for $T_e < 500$ eV α_{2Maxw} is much smaller than α_{Beam}. This can lead to significant discrepancy in electron temperature inferred from spectral plasma diagnostics with these two approaches.

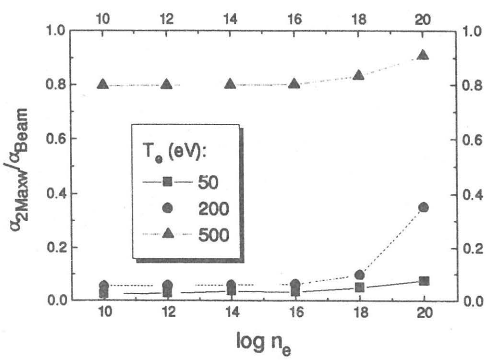

Fig. 1. The ratio $\alpha_{2Maxw}/\alpha_{Beam}$.