Effects of super-Gaussian electron velocity distribution functions on atomic kinetics and radiative emission of hot under-dense Gold plasmas

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Numerous studies in plasma physics are performed assuming that the electron distribution functions (EDFs) are Maxwell-Boltzmann or Fermi-Dirac distributions. However, these widely used assumptions appear to be invalid in various situations.

A source of non-Maxwellian EDF in a laser-produced plasma occurs when the inverse Bremsstrahlung process is the dominant heating mechanism. In the plasma zone where the laser energy is efficiently deposited, media are characterized by high temperatures, large density gradients, and EDFs depleted, both in their low- and the high-energy regions, compared to a Maxwellian distribution. It has been predicted [1] that such EDFs can be described as super-Gaussian (SG) distribution functions where the SG exponent (m) is greater than 2. Recently, the effects of such flat-top electron distributions on the crossed beam energy transfer and on the laser heating have been experimentally demonstrated in low-Z and mid-Z plasmas [2, 3].

Mega-Joule class laser-produced plasmas should enhance the presence of SG-like distributions during the laser heating of high-Z materials, since higher will be the values of the laser intensity and the average ionization, higher could be the deviation between the SG-like and the Maxwellian-Boltzmann distributions. This assumption has motivated the present study, where the effects of non-Maxwellian EDFs on properties of hot under-dense gold plasmas are numerically investigated for conditions existing in laser-heated hohlraums downstream the critical density. A non-thermal collisional-radiative model is used to perform the atomic kinetics and spectral emissivity calculations. Deviations from the case of the Maxwellian distribution, are examined as illustrated in Fig 1.

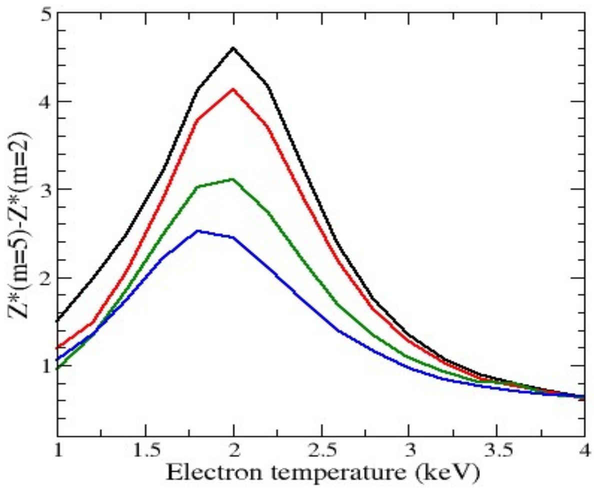

Figure 1. Deviation of Gold average ionizations calculated for two super-Gaussian exponent values (m = 2 and m = 5) as function of the electron temperature and for various electron densities: 10^{19} cm^{-3} (black line), 10^{20} cm^{-3} (red line), 5×10^{20} cm^{-3} (green line), and 10^{21} cm^{-3} (blue line).

References

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