Metastable State Populations in Laser Induced Plasmas

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Abstract

Laser ablation plasma has been used as a source of neutrals and ions. The purity of state of this source is critical to the measurement of collisional parameters such as the charge transfer rate coefficients between ions and neutrals used in the modeling of astrophysical plasmas. However, there appears to be some uncertainty on the presence of metastable state population in this source. We address this issue in this paper by reviewing theoretical and experimental evidences to show that the temperature of the laser-induced plasma is a rapidly decreasing function of time and that the temperature of the plasma is initially high but cools off rapidly by collision with the expanding plasma electrons as the neutrals and ions streams into to the vacuum. Similar to a supersonic jet, this rapid expansion of the plasma drastically lowers the internal energy of the neutrals and ions. Measurements on the time evolution of the population ratio of metastable state to ground state indicate that the population ratio freezes out at 3.5μs after the plasma is produced. The freeze-out population ratio suggests Te$\sim$1000 K. This measurement is consistent with the observations (1,2) that the charge transfer rate coefficient is independent of the power of the laser used in the production of the ions. We conclude that the metastable fraction in both the neutral and ion source must be negligibly small if the metastable state is more than 0.4 eV above the ground state.

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