Atomic processes in low-pressure argon afterglows

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Recently Celik et al. [1] presented a comprehensive description of the kinetic processes in a low-pressure noble-gas plasma afterglow. They supported their experimental findings by analytical models but some unknown quantities had to be adjusted by fitting the model predictions to experimental data. Hence, their analysis was, in part, only qualitative. The main obstacle preventing a more quantitative description arose from the complex population dynamics of the excited states of the atoms in a recombination-dominated afterglow.

We have now remedied this problem by constructing a complete collisional-radiative model of recombining noble-gas plasma. It concentrates on the highly excited Rydberg states, which play a dominant role in the electron capture by three-body collisions. The high probability of their reionisation keeps the populations of these high Rydberg states close to Saha equilibrium. This provides a gradual limitation of the states at which the electrons can be effectively captured, in contrast with the sharp cut-off introduced in the previous work.

The collisional-radiative model allows the calculation not only of the net recombination rate but also of a number of other important characteristics. These include, for example, electron heating due to the energy released by recombination as well as the temporal evolution of the excited states, with the metastable atoms being of greatest interest for plasma applications. The model is coupled with the equations for the temporal evolution of the electron density and temperature. This allows a full *ab initio* calculation of the temporal evolution of a number of important plasma characteristics, in particular the electron density and temperature as well as the metastable atom density. The only remaining input parameters for the calculation are the initial values of the quantities, which are taken from the experiment. The calculated and measured temporal evolutions of the various parameters are compared and an excellent quantitative agreement is found throughout. Somewhat surprisingly, it was found that a precise agreement is only possible when the effect of the extensive gas heating is taken into account that was not included in the work of Celic et al. [1].

References

[1] Y. Celik, Ts. V. Tsankov, M. Aramaki, S. Yoshimura, D. Luggenhölscher and U. Czarnetzki, *Phys. Rev.* E **85** (2012) 056401.