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Challenges in collisional-radiative modelling for low-temperature plasmas: EEDF, species density profiles, and collisional cross section data

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Collisional-radiative (CR) models in low-temperature plasmas are a widely investigated topic. These models can predict the metastable density, radical density, and the VUV photon flux from resonance states. Also, they can relate the emission line-ratios from excited species to the plasma parameters (e.g. electron density and temperature) when using optical emission spectroscopy. Although the CR models for low-temperature plasmas have been developed for several decades, they still face several challenges: (a) a Maxwellian EEDF is assumed in many models for simplicity but a large error can be introduced under more typical conditions with non-Maxwellian EEDFs; (b) homogenous density profiles for excited species are often used, though bounded plasmas are generally inhomogeneous; (c) the collisional cross section data for these models may have too large uncertainties. In this work, some recent progress in the research of CR models is reviewed, which attempts to overcome these challenges. A CR model with a variable EEDF profile (possibly Maxwellian or non-Maxwellian) has been developed. With this model the OES line-ratio method can obtain EEDFs in good agreement with those by Langmuir probe in low-pressure inductive/capacitive discharges. Further, a self-consistent CR model that additionally includes the radiation transfer equations is built. In this way, the assumption of a homogeneous density profile of excited species is avoided. The model can predict the actual density profile. At last, we discuss the recent works on measurements of collisional cross section using plasmas and lasers. In particular, we propose a novel approach, i.e. the pulsed laser induced photoelectron beam method, which in principle overcomes several limitations in the previous measurements. Based on these efforts, a new generation of CR models with a more accurate description of EEDF, species densities, and collisional process rates is supposed to come out in the future.