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Abstract

In electron-ion collisions recombination processes play a very important role. A good understanding of these processes in the laboratory enables development of theory, which is useful for plasma diagnostics. For example, recombination processes affect the state of astrophysical objects [1, 2], as well as nuclear fusion plasma [3, 4]. In many cases electron-ion interaction involves more than one electron. There, electron-electron interaction is a crucial aspect of these particular atomic reactions. This doctoral dissertation focuses on rare atomic processes both from theoretical and experimental perspectives.

In Highly Charged Ions Laboratory in the Institute of Physics of the Jagiellonian University, an electron beam ion trap (Dresden EBIT [5, 6], DREEBIT Co.) was installed in 2012. This compact room-temperature HCI-trap, equipped with an X-ray detector (XFlash 5030, Bruker Co.), opens a wide range of possibilities for studies of atomic processes associated with ion production and trapping in an EBIT [6].

The aim of this PhD dissertation is to collect experimental data and compare them with theoretical calculations done with the use of Flexible Atomic Code (FAC [7]). First examined process is called radiative recombination (RR). The capture of a free electron into a bound state of an ion is accompanied by the emission of a photon. It is worth mentioning, that a good resolution of RR spectra for bare argon ions (Ar^{18+}) is an evidence of EBIT great research opportunities [8, 9, 10]. Secondly, resonant recombination involving more than one electron has been discussed. The most basic of these resonant processes is dielectronic recombination (DR) where a free electron is captured into a bound state of an ion with the simultaneous excitation of a core electron [11, 12, 13, 14, 15, 16, 17]. These resonantly populated excited states decay via characteristic K-shell X-ray emission. Very good resolution of the X-ray detector enabled the K-LL DR resonances to be distinguished for He- up to C-like Ar ions [8, 18, 19]. In the observed X-ray energy region, in addition to the DR, the intrashell tricelectronic recombination (intrashell TR) has been seen [8].

The last part of the presented studies is dedicated to the multishell TR, specifically to the KK TR [18]. Here, the resonant capture of a free electron to an ion-bound state transfers simultaneously two K-shell electrons to a higher atomic shell. This way, a doubly-excited K-shell state is produced and, in most cases, it decays via emission of two photons. The first transition to the empty K shell is responsible for emission of the K^h hypersatellite photon with an energy slightly higher than energy of the following K^s satellite transition. A maximum-like behavior of the intensity ratio between K^h_α and K^s_α has been reported. This behavior is a fingerprint of the investigated TR process. Finally,

to the best of my knowledge, this is the first successful observation of this TR process [20, 18].

One has to add, that the presented research analysis was supplemented with orginal methods of determination of the charge state distribution of ions in the UJ-EBIT plasma. These methods were based on the analysis of the X-ray lines profile [21].

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