Electron capture at low velocity in the collision of Ar^{17+} ions with atoms, clusters and solids

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In the low energy regime (below a few tens of keV/q), the investigation of collisions of Highly Charged Ions (HCI) with matter is important for fundamental understanding of atomic processes occurring, for example, in various plasma environments. The x-ray spectroscopy of excited states of HCI formed by capture of target electrons has proved to be a very powerful tool to study the interaction dynamics of ions with atoms [1] or solids (bulk or surfaces) [2]. We present here new results on collisions of Ar^{17+} ions (v = 0.53 a.u.) with gaseous targets (Ar and N_2), rare-gas clusters of nanometer size and thin carbon foils from a few to 100 µg/cm². The excited ions stabilize via radiative decay and autoionization. X-rays emitted by HCI are recorded by solid state detectors and a high-resolution high-transmission Bragg spectrometer.

In case of collisions with atoms, the emission of argon helium-like x-ray transitions has been observed with an unprecedent resolution (resolving power of 1000 around 3-4 keV) allowing us to separate all the $1sn\ell \rightarrow 1s^2$ lines from n = 2 to n = 10 (Fig. 1). Such investigation has brought new insights in ion-atom collision, especially regarding the contribution of multiple capture processes and the formation of metastable states [3]. It offers as well new benchmarks for theory [4].

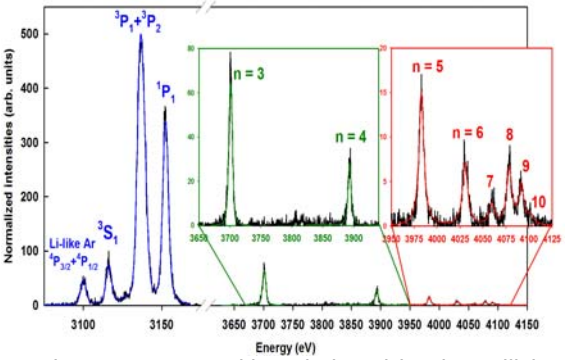

Fig. 1: X-ray transitions induced by the collision of 15 keV/q Ar^{17+} ions with N_2 target.

The spectrum over the same x-ray energy range is drastically different when using a thin solid target. The deexcitation from Ar^{16+} excited states has entirely disappeared while those from lower charge states are clearly visible down to Ar^{9+}. It is indeed the result of a complex competition between various processes, namely multistep capture, side feeding mechanisms and Auger effect [5]. The use of clusters bridges the gap between the isolated atom and the solid. They offer the possiblity to easily change the surface/volume ratio. In case of the interaction of a cluster jet that consists of a mixture of clusters and free atoms with slow HCI, the classical capture radius is of the same order of magnitude as the cluster radius (~ nm). Consequently, in the single collision regime, the X-ray yield is drastically reduced due to the clustered part of the jet compared to an effusive jet (at same mean atomic density). This cluster effect signs the HCI-cluster interaction when X-ray spectroscopy technique is used. More details will be given and discussed during the conference.

References:
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