Electron capture at low velocity in the collision of Ar\textsuperscript{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 \cite{1} or solids (bulk or surfaces) \cite{2}. We present here new results on collisions of Ar\textsuperscript{17+} ions (v = 0.53 a.u.) with gaseous targets (Ar and N\textsubscript{2}), rare-gas clusters of nanometer size and thin carbon foils from a few to 100 µg/cm\textsuperscript{2}. 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 unprecedented resolution (resolving power of 1000 around 3-4 keV) allowing us to separate all the 1s\textsubscript{n}\rightarrow1s\textsuperscript{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 \cite{3}. It offers as well new benchmarks for theory \cite{4}.

The spectrum over the same x-ray energy range is drastically different when using a thin solid target. The deexcitation from Ar\textsuperscript{16+} excited states has entirely disappeared while those from lower charge states are clearly visible down to Ar\textsuperscript{9+}. It is indeed the result of a complex competition between various processes, namely multistep capture, side feeding mechanisms and Auger effect \cite{5}. The use of clusters bridges the gap between the isolated atom and the solid. They offer the possibility 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 (\approx 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 signifies the HCI-cluster interaction when X-ray spectroscopy technique is used. More details will be given and discussed during the conference.

References: