Monte Carlo Simulations of Atomic Processes at the Gas Jet Target of the ESR Storage Ring

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In order to analyze x-ray spectra produced in collisions of fast ions with a gas-jet target of a storage ring, at a high level of accuracy, detailed information on the beam and the target geometry as well as on the parameters of the detectors used (position, size, efficiency) has to be considered [1]. In many cases a detailed response of the detectors upon variation of diverse parameters can be known only if computer simulated events are modeled and analyzed [2]. This allows to reveal the importance of these parameters and, as a consequence, to optimize experimental set-ups.

In the following an universal Monte Carlo simulation of atomic collision experiments, conducted at the gas-jet target of a storage ring, is presented. The quality of the computer code was tested by comparing the Monte Carlo simulated data with experimental spectra obtained at the ESR storage ring of GSI in Darmstadt.

The developed Monte Carlo program generates x-ray spectra collected in the laboratory frame due to encounters of heavy ions with atoms or molecules of a jet target at projectile velocities close to the speed of light. The program takes into account most of the parameters which determine the spectral distribution of the x-ray spectra. In particular, the overlap of an extended jet target and an extended ion beam is considered. The x-ray emitting target region can be surrounded by an array of x-ray detectors [4]. We assumed that the target and the beam density profiles are given by Gaussian distributions with the center of the reference system located at the center of the collision chamber. The program can simulate various radiative processes, e.g. Radiative Electron Capture (REC) [3] or the emission of characteristic projectile x-rays. Besides that, background photons can be generated with the presumed energy distribution. A detailed description of the program was already presented [5].

As an example, the K-REC x-ray spectra, observed by means of a planar Ge(i) detector at a backward angle of 132^o were simulated and compared to the experimental data accumulated for collisions of U^{92+} ions with gaseous targets at an energy of 358 MeV/u. Details of this experiment are reported elsewhere [6]. In the calculations the corresponding Compton profiles for the Ar- and the N_2-target are taken from [7]. Note, that for the latter case the molecular character of the target was not considered. In Fig. 1 a comparison of the simulated and measured spectra is displayed. A very good agreement between experiment and Monte Carlo data is to be noted. In particular, due to the stronger binding of the K-shell electrons in Ar, the wings of the REC distribution are considerably broader than for the N_2-target which is nicely reproduced in the simulated spectra.

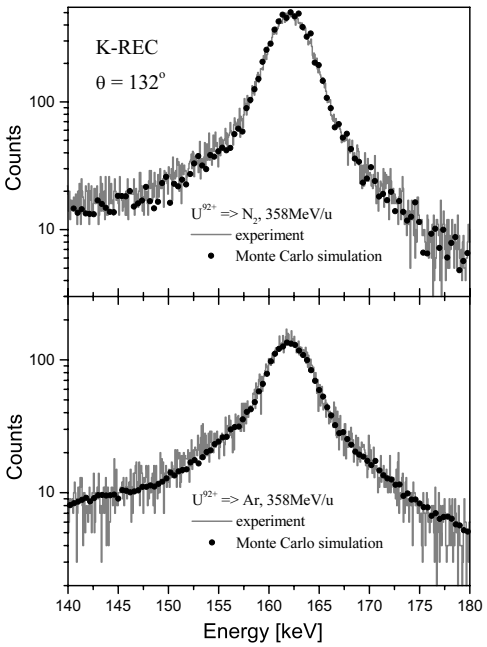

Figure 1: A comparison of experimental and simulated K-REC spectra obtained in collisions of U^{92+}-ions with an N_2-target and a Ar-target at 358 MeV/u.

The Monte Carlo code discussed provides us with valuable information on the structure of x-ray spectra which are produced in collisions of fast ions with a gas-jet target. Most important, it allows for a precise determination of the overall detection efficiencies required for accurate cross-section determinations. Currently, simulations of an already performed experiment on angular distributions of REC as well as on a planned experimental identification of higher-order corrections to the radiative electron capture process are in progress.

References

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