Relativistic calculations of x-ray emission following a Xe-Bi^{83+} collision *

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Experimental investigations aimed at the comprehensive study of various processes in low-energy heavy ion-atom collisions are anticipated at GSI and FAIR facilities (Darmstadt, Germany) [1, 2, 3] and require the corresponding theoretical calculations. In a recent experiment [4], the intensities of the post-collisional x-ray emissions have been resolved for collisions of Bi^{83+} ions with Xe target atoms at the projectile energy 70 MeV/u. In the present contribution we study the x-ray emission following the collision theoretically [5].

At this energy the ionization of the target is the dominant process, but the target excitation and the electron capture by the projectile ion are also possible. The excited xenon and bismuth ions decay via Auger processes or radiatively. In any case, the de-excitation processes (Auger or radiative decays) take much more time than the electronic dynamic processes during the collision. Therefore, the collisional and the post-collisional decay dynamics can be viewed as being independent from each other and thus we can treat them separately.

For the collision part, we solve the time-dependent Dirac equation within the semi-classical approximation and an independent electron model using the coupled-channel approach with the atomic-like Dirac-Fock-Sturm orbitals [6, 7]. The many-electron excitation, ionization and charge-transfer probabilities are calculated in terms of single-particle amplitudes employing the formalism of inclusive probabilities [8]. The inner-shell atom/ion processes are comprehensively studied and the corresponding probabilities are presented as functions of the impact parameter. As an example, one can see the probabilities of the Xe q-K-shell-vacancy production in Fig. 1.

The analysis of the post-collisional processes resulting in the x-ray emission is based on the fluorescence yields, the radiation and Auger decay rates, and allows to derive intensities of the x-ray emission. The relative intensities and comparison with the experimental data [4] are presented in Table 1. A reasonable agreement between the theoretical results and the experimental data is observed. The theoretical study demonstrates a very significant role of the relativistic effects, up to 50% for the bismuth x-ray radiation intensities. Thus, investigations of heavy highly charged ion-atom collisions seem very promising for tests of relativistic and QED effects in scattering processes.

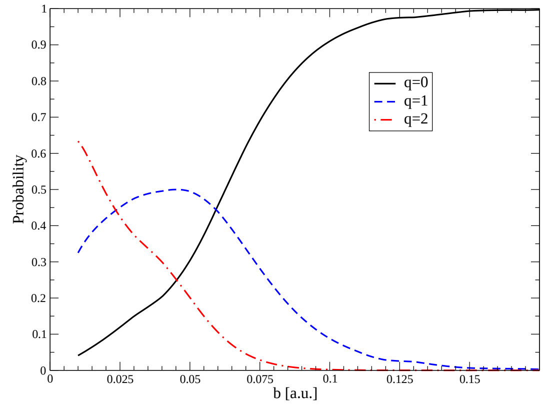

Figure 1: The probabilities of the Xe q-K-shell-vacancy production in the Xe-Bi^{83+} collision as functions of the impact parameter b.

Table 1: Relative intensities of the x-ray radiation for the Xe-Bi^{83+} collision. Both the relativistic (Rel.) and nonrelativistic (Nonrel.) results of the theoretical calculations are presented.

	Theory [5]		Exp. [4]
	Rel.	Nonrel.	
(Xe, L)/(Xe, K)	4.2(6)	4.4	3.6(2)
(Bi, K_{α_1})/(Xe, K)	0.43(14)	0.62	0.59(3)
(Bi, K_{α_2})/(Xe, K)	0.83(30)	0.88	0.69(3)

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