Double-electron-capture processes in low- and intermediate-energy \( \text{Th}^{90+} - \text{Ru}^{42+}(1s^2) \) collisions

Y S Kozhedub\textsuperscript{1,}\textsuperscript{*}, A I Bondarev\textsuperscript{1,2}, X Cai\textsuperscript{3}, X Ma\textsuperscript{3}, G Plunien\textsuperscript{4}, V M Shabaev\textsuperscript{1}, C Shao\textsuperscript{3}, B Yang\textsuperscript{3}, D Yu\textsuperscript{3}

\textsuperscript{1}Department of Physics, St. Petersburg State University, St. Petersburg, 199034, Russia
\textsuperscript{2}Center for Advanced Studies, Peter the Great St. Petersburg Polytechnic University, Polytechnicheskaya 29, St. Petersburg, 195251, Russia
\textsuperscript{3}Institute of Modern Physics, Chinese Academy of Sciences, Nanchang rd. 509, Lanzhou, 730000, China
\textsuperscript{4}Institut für Theoretische Physik, Technische Universität Dresden, Mommsenstraße 13, Dresden, D-01062, Germany

Synopsis

Double-electron-capture (DEC) processes in the \( \text{Th}^{90+} - \text{Ru}^{42+}(1s^2) \) collisions are studied for a wide energy collision region from 0.5 to 50 MeV/u. The total cross sections as well as impact parameter dependencies of various DEC processes are obtained. Our study demonstrates a very significant role of the relativistic effects, which become crucial in the low-energy regime.

Heavy-ion collisions play a very important role in investigations of the relativistic quantum dynamics of electrons in presence of strong electromagnetic fields [1]. A special interest is attracted to resonance processes, which can be very sensitive to relativistic and quantum electrodynamical effects.

In the present work we theoretically study double-electron-capture (DEC) processes in the \( \text{Th}^{90+} - \text{Ru}^{42+}(1s^2) \) collisions, where the ground state of ruthenium and \( n = 2 \) states of thorium are in a resonance. The calculations are performed for a wide energy collision region ranging from 0.5 to 50 MeV/u. A semiclassical atomic Dirac-Fock-Sturm orbital coupled-channel method within an independent particle model is used [2, 3]. The total and state-selective DEC cross sections as well as the impact parameter dependencies are evaluated. A few examples are presented in Figs. 1-2. Special attention is paid to investigation of the relativistic effects, which role is very significant and becomes crucial in the the low-energy regime.

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References


*E-mail: y.kozhedub@spbu.ru

![Figure 1](image1.png) 2p2p'-selective DEC cross sections for electron capture to the \( \text{Th}^{88+} \) ion. The non-relativistic results are marked NR.

![Figure 2](image2.png) 2s2p_{3/2} DEC probabilities weighted by the impact parameter for the \( \text{Th}^{90+} - \text{Ru}^{42+}(1s^2) \) @ 50 MeV/u collisions as functions of the impact parameter. The relativistic results ("Rel") and non-relativistic ones ("NR") are presented.