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Coupled-state molecular treatment of charge-transfer in slow heavy ion-ion collisions: Bi^{4+} - Bi^{4+}

The study of charge transfer in collisions between identical heavy ions is relevant to efficiency of future accelerators and storage rings. Charge-changing collisions between the ions within the beams occur at keV relative transverse energies due to betatron oscillations. Recently the total charge transfer cross sections for collisions between quadruply charged bismuth ions were measured by Erhard Salzborn et al. and expected particle losses due to such collisions from 100 Tm synchrotron were estimated.

The purpose of our study was two-electron multi-state calculation of charge transfer and excitation cross section for collisions:

$$(1)\quad {}^2\mathrm{S}\ \mathrm{Bi}^{4+}(6s) + {}^2\mathrm{S}\ \mathrm{Bi}^{4+}(6s) \rightarrow {}^1\mathrm{S}\ \mathrm{Bi}^{3+}(6s^2) + {}^1\mathrm{S}\ \mathrm{Bi}^{5+}(5d^{10}),\quad \Delta E_1 = 11,64\ eV$$

$$(2)\quad {}^2\mathrm{S}\ \mathrm{Bi}^{4+}(6s) + {}^2\mathrm{S}\ \mathrm{Bi}^{4+}(6s) \rightarrow {}^3\mathrm{P}\ \mathrm{Bi}^{3+}(6s6p) + {}^1\mathrm{S}\ \mathrm{Bi}^{5+}(5d^{10}),\quad \Delta E_2 = 20,27\ eV$$

$$(3)\quad {}^2\mathrm{S}\ \mathrm{Bi}^{4+}(6s) + {}^2\mathrm{P}\ \mathrm{Bi}^{4+}(6p) \rightarrow {}^1\mathrm{P}\ \mathrm{Bi}^{3+}(6s6p) + {}^1\mathrm{S}\ \mathrm{Bi}^{5+}(5d^{10}),\quad \Delta E_3 = 10,44\ eV$$

$$(4)\quad {}^2\mathrm{S}\ \mathrm{Bi}^{4+}(6s) + {}^2\mathrm{P}\ \mathrm{Bi}^{4+}(6p) \rightarrow {}^3\mathrm{P}\ \mathrm{Bi}^{3+}(6s6p) + {}^1\mathrm{S}\ \mathrm{Bi}^{5+}(5d^{10}),\quad \Delta E_4 = 10,44\ eV$$

Here $\Delta E_{1,2}$ are the energies of resonance defect of charge transfer obtained from ionic total energy Hartree-Fock-Dirac (HFD) calculations. For triplet collisions the energy of resonance defect is more higher (ΔE=20, 27 eV) and therefore they were discarded in our preliminary study (as well as reactions (3) and (4)). The study of charge transfer and excitation for reactions was performed within the framework of the method of perturbed stationary states. We adopted the five-state CI gerade and ungerade screened diatomic molecular orbital (SDMO) expansion to obtain the transition amplitude in the impact parameter approach.