Photorecombination of berylliumlike and boronlike silicon ions

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Synopsis Absolute rate coefficients for electron-ion recombination of astrophysically relevant Si^{9+} and Si^{10+} ions were measured at a heavy-ion storage ring. Hyperfine quenching of long-lived metastable levels was used for preparing practically pure ground-state beams in the storage ring. From the measured results rate coefficients for recombination of Si^{9+} and Si^{10+} ions in a plasma are derived and represented by simple parameterizations.

We report measured rate coefficients for electron-ion recombination of Si^{10+} forming Si^{9+} and of Si^{9+} forming Si^{8+}, respectively [1]. The measurements were performed using the electron-ion merged-beams technique at the Heidelberg heavy-ion storage ring TSR [2]. Electron-ion collision energies ranged from 0 to 50 eV for Si^{9+} and from 0 to 2000 eV for Si^{10+}, thus extending previous measurements for Si^{10+} [3] to much higher energies (Fig. 1). Experimentally-derived rate coefficients for the recombination of Si^{9+} and Si^{10+} ions in a plasma are presented along with simple parametrizations. These rate coefficients are useful for the modeling of the charge balance of silicon in photoionized plasmas (Si^{9+} and Si^{10+}) and in collisionally ionized plasmas (Si^{10+} only). In the corresponding temperature ranges, the experimentally-derived rate coefficients agree with the latest corresponding theoretical results within the experimental uncertainties.

One of the hallmarks of the storage-ring technique is that it allows for the preparation of ions in well defined energy levels. This has been exploited in particular for reducing the Si^{10+} ion beam contamination by long-lived $2s\,2p\ ^3P$ metastable levels to almost insignificance. To his end, the isotope ^{29}Si was used in the Si^{10+} experiment. For this isotope, with nonzero nuclear spin, hyperfine quenching shortens the $^3P_0$ lifetime by several orders of magnitude [4, 5] as compared to the more abundant isotope ^{28}Si. In fact, the storage-ring technique can also be used for precisely measuring these hyperfine induced lifetimes [6, 7]. Hyperfine quenching has been exploited already previously for state-preparation in a storage-ring measurement of electron-impact ionization of Be-like sulfur ions [8].

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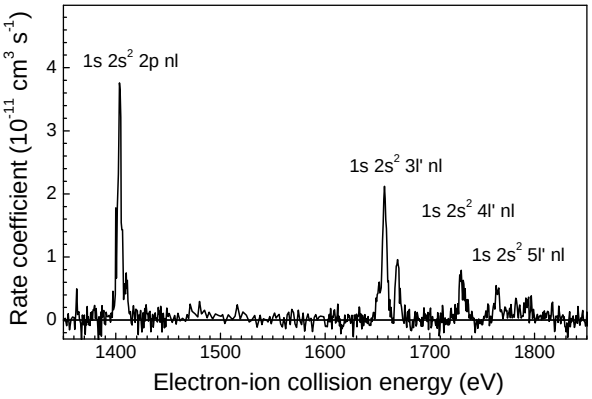

Figure 1. High-energy portion of the measured merged-beams rate coefficient (solid black line) for photorecombination of Si^{10+} in the energy range of dielectronic recombination resonances associated with K-shell excitations [1]. Resonance groups are labelled by the according $1s^2\,2s^2 \rightarrow 1s\,2s^2\,N'l'$ core excitations.

References

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