Photorecombination of berylliumlike and boronlike silicon ions

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Synopsis Absolute rate coefficients for electron-ion recombination of astrophysically relevant Si9+ and Si10+ 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 Si9+ and Si10+ ions in a plasma are derived and represented by simple parameterizations.

We report measured rate coefficients for electron-ion recombination of Si10+ forming Si9+ and of Si9+ forming Si8+, 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 Si9+ and from 0 to 2000 eV for Si10+, thus extending previous measurements for Si9+ [3] to much higher energies (Fig. 1). Experimentally-derived rate coefficients for the recombination of Si9+ and Si10+ 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 (Si9+ and Si10+) and in collisionally ionized plasmas (Si10+ 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 Si10+ ion beam contamination by long-lived 2s2p 3P metastable levels to almost insignificance. To his end, the isotope 28Si was used in the Si10+ experiment. For this isotope, with nonzero nuclear spin, hyperfine quenching shortens the 3P lifetime by several orders of magnitude [4, 5] as compared to the more abundant isotope 29Si. 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 Si10+ in the energy range of dielectronic recombination resonances associated with K-shell excitations [1]. Resonance groups are labelled by the according 1s22s2 1s22s2 2l core excitations.

References

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