Storage-ring measurement of the hyperfine induced 2s2p $^3P_0 \rightarrow 2s^2\ ^1S_0$ transition rate in beryllliumlike sulfur

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Storage-ring measurement of the hyperfine induced $2s2p\ ^3P_0 \rightarrow 2s^2\ ^1S_0$ transition rate in berylliumlike sulfur

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Synopsis The hyperfine induced $2s2p\ ^3P_0 \rightarrow 2s^2\ ^1S_0$ transition rate in Be-like $^{33}S^{12+}$ has been measured employing electron-ion recombination spectroscopy at a heavy-ion storage ring. The measured value of 0.094(4) s^{-1} is in excellent agreement with the results of the most recent theoretical calculations.

Atoms and ions in metastable excited states with very small electromagnetic transition rates are promising systems for energy storage, for realizing ultraprecise atomic clocks, for the diagnostic of astrophysical media regarding the competition of radiative and non-radiative processes, for realizing novel types of cold atomic gases, and for probing fundamental correlation effects in the bound states of few-electron systems. Extremely long-lived atomic states are highly sensitive to correlations within the atomic shell and even to the nuclear structure of the ions. One such state is the lowest excited level of berylliumlike ions, $2s\,2p\ ^3P_0$, which cannot decay via a one-photon transition. However, if the nucleus has a magnetic moment then the hyperfine interaction can quench the $2s\,2p\ ^3P_0$ level. Here we report on a storage-ring measurement of the hyperfine induced (HFI) $2s2p\ ^3P_0 \rightarrow 2s^2\ ^1S_0$ transition rate in berylliumlike S^{12+}.

The left panels in figure 1 display experimental dielectronic recombination (DR) spectra of two S^{12+} isotopes, i.e., $^{32}S^{12+}$ and $^{33}S^{12+}$. The most prominent resonance features in both spectra are due to DR of $2s^2\ ^1S_0$ ground state ions. In the $^{32}S^{12+}$ spectrum an additional feature at ∼0.4 eV is caused by DR of metastable $2s2p\ ^3P_0$ ions which had a fractional abundance of about 5% in the ion beam. This fraction is hyperfine quenched when $^{33}S^{12+}$ ions with a nuclear spin of 3/2 are used. Consequently, the related DR resonance is absent in the $^{33}S^{12+}$ spectrum.

The right panels of figure 1 show the recombination signal as function of storage time with the electron-ion collision energy tuned to the hyperfine quenched resonance. Clearly the $^{33}S^{12+}$ decay curve exhibits a fast decaying component which is not present in the $^{32}S^{12+}$ curve. A detailed analysis of the decay curves allows for the extraction of the HFI $2s2p\ ^3P_0 \rightarrow 2s^2\ ^1S_0$ transition rate from the measurements [1]. Our value of 0.094(4) s^{-1} agrees with the most recent theoretical results [2, 3] within the 4% experimental uncertainty. Furthermore, we find that the experimental value is insensitive to a factor-of-two variation of the magnetic field of the storage ring bending magnets.

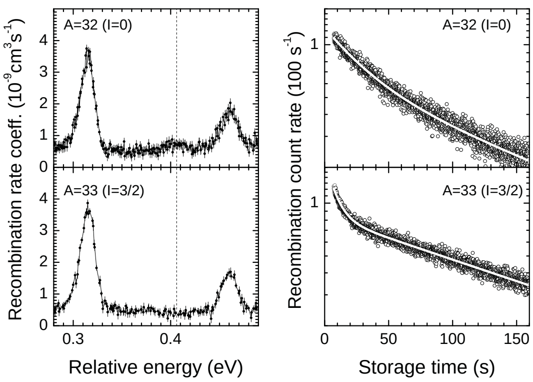

Figure 1. Left panels: Comparison between DR spectra of $^{32}S^{12+}$ (upper curve) and $^{33}S^{12+}$ (lower curve). The resonance at ∼0.4 eV is hyperfine-quenched in the $^{33}S^{12+}$ spectrum. Right panels: Measured recombination count rates as function of storage time with the electron-ion collision energy tuned to ∼0.4 eV. 'A' and 'I' denote the nuclear mass number and the nuclear spin of the specific isotope, respectively.

References

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