Storage-ring measurement of the hyperfine induced 2s2p 3P0 → 2s2 1S0 transition rate in berylliumlike sulfur

S. Schippers1, D. Bernhardt2, M. Grieser1, M. Hahn3, C. Krantz1, M. Lestinsky4, A. Müller*, O. Novotny5, R. Repnow7, D. W. Savin3, A. Wolf1

*Institut für Atom- und Molekülphysik, Justus-Liebig-Universität Giessen, 35392 Giessen, Germany
1Max-Planck-Institut für Kernphysik, 69117 Heidelberg, Germany
2GSI Helmholtzzentrum für Schwerionenforschung mbH, 64291 Darmstadt, Germany
3Columbia Astrophysics Laboratory, Columbia University, New York 10027, USA

Synopsis The hyperfine induced 2s2p 3P0 → 2s2 1S0 transition rate in Be-like 33S12+ 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, 2s2p 3P0, which cannot decay via a one-photon transition. However, if the nucleus has a magnetic moment then the hyperfine interaction can quench the 2s2p 3P0 level. Here we report on a storage-ring measurement of the hyperfine induced (HFI) 2s2p 3P0 → 2s2 1S0 transition rate in berylliumlike 33S12+.

The left panels in figure 1 display experimental dielectronic recombination (DR) spectra of two S12+ isotopes, i.e., 32S12+ and 33S12++. The most prominent resonance features in both spectra are due to DR of 2s2 1S0 ground state ions. In the 32S12+ spectrum an additional feature at ∼0.4 eV is caused by DR of metastable 2s2p 3P0 ions which had a fractional abundance of about 5% in the ion beam. This fraction is hyperfine quenched when 33S12+ ions with a nuclear spin of 3/2 are used. Consequently, the related DR resonance is absent in the 33S12+ 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 33S12+ decay curve exhibits a fast decaying component which is not present in the 32S12+ curve. A detailed analysis of the decay curves allows for the extraction of the HFI 2s2p 3P0 → 2s2 1S0 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 32S12+ (upper curve) and 33S12+ (lower curve). The resonance at ∼0.4 eV is hyperfine-quenched in the 33S12+ 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
[1] S. Schippers et al 2012 Phys. Rev. A 85 012513
[2] K. T. Cheng et al 2008 Phys. Rev. A 77 052504
[3] M. Andersson et al 2009 Phys. Rev. A 79 032501

1E-mail: Stefan.Schippers@iamp.physik.uni-giessen.de