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Near-Threshold Dielectronic Recombination Studies of Si-Like Ions

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Synopsis Dielectronic recombination rate coefficients are computed for the Si-like isoelectronic sequence, focusing on the near-threshold resonances of S^{2+}.

We present dielectronic recombination (DR) calculations for Si-like ions, and the important S^{2+} case in particular. This work has been motivated by the astrophysical importance of the S^{2+} DR rate in determining the sulfur ionization balance in the Orion nebula, a photoionized plasma corresponding to low-energy electrons [1]. All the calculations are performed using the atomic structure and collision code AUTOSTRUCTURE [2], a multi-configuration Breit-Pauli (MCBP) method. Energy levels and transition rates are computed in LS- and IC- coupling approximations. Energy positions of near-threshold bound and resonance states are investigated in particular. Table 1 lists three prominent bound $(N+1)$-electron states and one strong resonance state, relative to the $S^{2+}(3s^2 3p^2\,{}^3P_0)$ threshold. On comparison with available NIST data, the theoretically predicted energies are overestimated by 0.25-0.45 Ryd. There are no NIST or other data available for the given resonance state [3].

Ionic state	Energy (Ryd)	
	Present	NIST
$S^+\ 3s3p^4(^2S_{1/2})$	-0.175	-0.623
$S^+\ 3s3p^4(^2P_{3/2})$	-0.142	-0.389
$S^+\ 3s3p^4(^2P_{1/2})$	-0.137	-0.386
$S^+\ 3s3p^3 3d(^4D_{7/2})$	+0.321	

We conclude from the overestimates observed in the bound energy values that the energy of the resonance is likewise overestimated. It could also mean that low-temperature (characteristic of photoionized plasmas) DR should be enhanced by the resonance position. Fig. 1 shows the computed DR cross-sections and rate coefficients for S^{2+}, including also the results corresponding to a global shift of low-lying, near-threshold resonances. The uncertainties in these resonances is seen to translate to a large uncertainty in the DR rate coefficient at lower-temperatures such as that of Orion nebula ($T \sim 10^4$ K). This work comprises a part of our program to assemble a general DR data base for all ions for modeling dynamic finite plasmas.

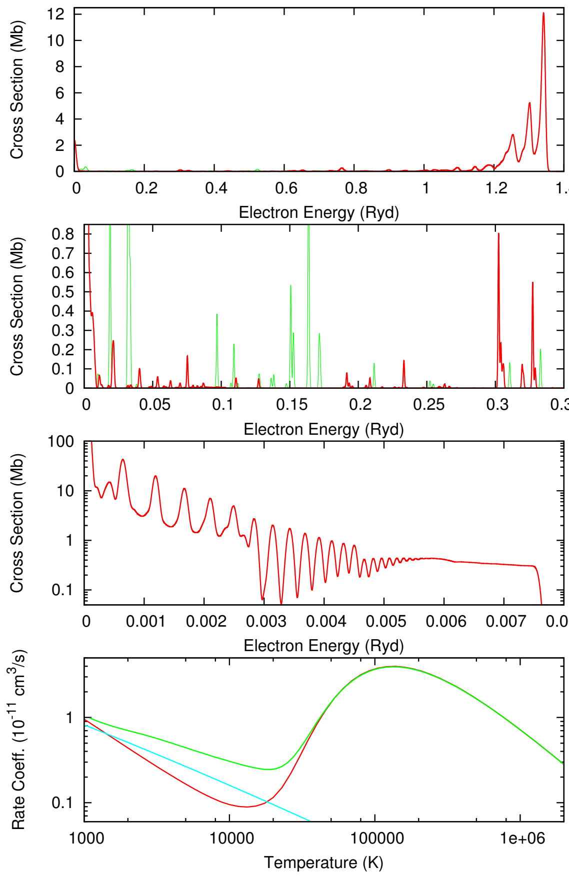

Figure 1. DR cross section (upper three panels, convolved with FWHM Gaussians convolutions of 0.01 and 0.001 Ryd in descending order) and Maxwellian-averaged rate coefficient (lower panel). *Ab initio* results are in red and those with all $(N+1)$-electron resonances shifted by -0.157 Ryd are in green. The computed RR rate coefficient is the cyan curve in the lower panel.

References

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