

# A Perturbative Treatment For the Dielectronic Recombination of the Si-Like Isoelectronic Sequence

J. Kaur,<sup>\*1</sup> T. W. Gorczyca,<sup>\*2</sup> and N. R. Badnell<sup>†</sup>

<sup>\*</sup>Department of Physics, Western Michigan University, Kalamazoo, MI 49008-5252, USA

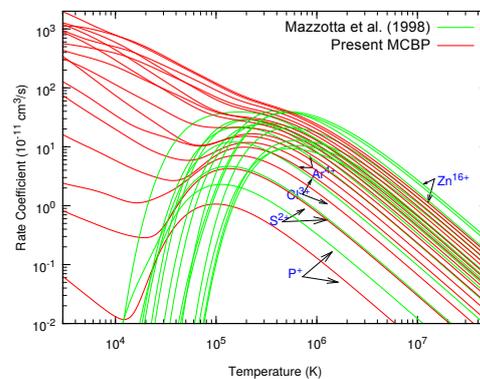
<sup>†</sup>Department of Physics, University of Strathclyde, Glasgow G4 0NG, United Kingdom

**Synopsis** A detailed investigation of Si-like dielectronic recombination is performed for the entire Si-like isoelectronic sequence using a perturbative multi-configurational Breit-Pauli method.

We present total and final-state level-resolved DR rate coefficients for the silicon-like ions from  $P^+$  through  $Zn^{16+}$ , relevant to the modelling of astrophysical and laboratory plasmas, and for the ions  $Kr^{22+}$ ,  $Mo^{28+}$  and  $Xe^{40+}$  that are important in fusion research. Both  $\Delta n_c = 0$  and  $\Delta n_c = 1$  core excitations are included in  $LS$  and  $IC$  (intermediate coupling) schemes. Our calculations were performed using the atomic structure and collision code AUTOSTRUCTURE [1, 2], a perturbative multi-configurational Breit-Pauli (MCBP) method that relies on the independent processes, isolated resonance, distorted-wave (IPIRDW) approximation. Energy levels, radiative rates, and autoionization rates are calculated in both  $LS$  and  $IC$  approximations, where the latter also include semi-relativistic corrections such as the spin-orbit interaction that gives rise to significant fine-structure effects. The electronic orbitals are obtained using the Thomas-Fermi-Dirac-Amaldi (TFDA) model potential, where the scaling parameters  $\lambda_{nl}$  are optimized so as to reproduce the experimental (NIST) fine-structure splitting for the low-lying levels.

The computed Maxwellian-averaged DR rate coefficients for the entire silicon-like isoelectronic sequence are shown in Fig. 1 and compared with the earlier recommended data of [3, 4], as incorporated in all previous plasma models. Those data were based on crude  $LS$  calculations, and thus were unable to reproduce the low-temperature DR contributions that are due to fine-structure splitting [5]. This effect becomes more predominant with increase in the effective charge  $z$ . At higher temperatures, the more complete IC cross sections in-

stead lie below the non-relativistic  $LS$  results, again due to less obvious fine-structure effects [5]. This work is a part of an assembly of a dielectronic recombination database for the modelling of dynamic finite-density plasmas.



**Figure 1.** Comparison between present Maxwellian-averaged DR rate coefficients and recommended compilation [3, 4] for the entire silicon-like isoelectronic sequence.

## References

- [1] N. R. Badnell 1986 *J. Phys. B* **19** 3827
- [2] N. R. Badnell 1997 *J. Phys. B* **30** 1
- [3] P. Mazzotta, G. Mazzitelli, S. Colafrancesco and N. Vittorio 1998 *Astron. Astrophys. Suppl. Ser.* **133** 403
- [4] G. Mazzitelli and M. Mattioli 2002 *at. data nucl. data tables* **82** 313
- [5] S. A. Abdel-Naby, D. Nikolić, T. W. Gorczyca, K. T. Korista and N. R. Badnell 2012 *Astron. Astrophys.* **537** A40

<sup>1</sup>E-mail: [fnu.jagjitkaur@wmich.edu](mailto:fnu.jagjitkaur@wmich.edu)

<sup>2</sup>E-mail: [Thomas.Gorczyca@wmich.edu](mailto:Thomas.Gorczyca@wmich.edu)

