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Photoionization and Electron-Ion Recombination of Cr I

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Synopsis Photoionization and electron-ion recombination are inverse processes. These can be studied in a self-consistent manner using the unified method. Results using the method are presented for the two processes of Cr I, $\text{Cr I} + h\nu \leftrightarrow \text{Cr II} + e$. Study shows that photoionization in the low energy region is dominated by high peak resonances and an enhancement in the background cross section at the energy of the first excited threshold, $3d^4 4s\ ^5D$ state, of the core Cr II. Prominent PEC (phot-excitation-of-core) resonance is found to dominate high energy region photoionization of the excited states. The total recombination rate, which includes both the radiative and dielectronic recombination, shows a peak at a relatively low temperature, around 630 K, and then another one at around 40,000 K.

Neutral Chromium, Cr I, has been studied by many investigators because of its presence in astronomical objects. However, the studies are mainly for photoionization, but do not include excited states and resonant features. Total electron-ion recombination rates needed in abundance calculations are also not available. The present work report study of both the processes using a large wave function expansion. The unified method used in the work is based on close-coupling approximation and R-matrix method. It (i) subsumes both the radiative and dielectronic recombinations for the total rates and (ii) provides self-consistent sets of photoionization cross sections σ_{PI} , and state-specific and total recombination rates α_{RC} .

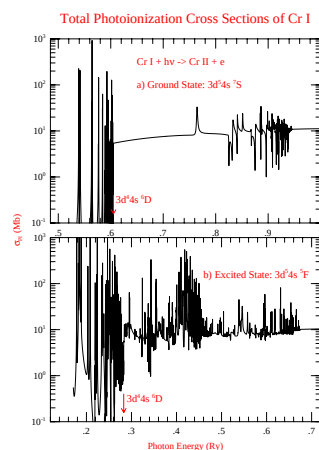


Fig. 1. Photoionization cross sections of the ground and excited states of Cr I.

We see existence of extensive high-peak resonances near the first ionization threshold (Fig. 1) representing high probabilities of both photoionization and recombination of the atom in the low energy region. The energy region has almost zero background until it is enhanced at the first ex-

cited core threshold, $3d^4 4s\ ^6D$, which is 0.11 Ry above the ionization threshold. PEC resonance due to the dipole allowed transition in the core is found in photoionization cross sections of most of the excited states.

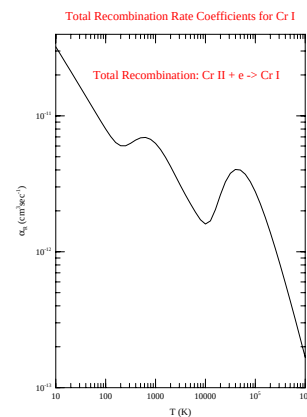


Fig. 2. Total electron-ion recombination of Cr I ($e + \text{Cr II} \rightarrow \text{Cr I}$).

Both the state-specific and total recombination rates are presented. The total recombination rate shows two DR peaks, one at a relatively low temperature, at 630 K which can explain formation and existence of neutral Cr in interstellar medium.

The ground state does not dominant to the total recombination rate. The excited state, $3d^5 4p(^7P^o)$, is found to be an important contributor above 11,000 K because of its high DR peak. Most of the states show one high temperature DR peak. State-specific recombination rates are needed for determination of level populations and formation of cascade matrices.

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