

RYDBERG ATOMS IN ASTROPHYSICAL PLASMAS: MODELING AND DATA RESOURCES

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The dissociative recombination (DR) of the NS^+ molecular ion with free electrons is a pivotal reaction in interstellar chemistry and laboratory plasma modeling, influencing the abundance and lifetimes of nitrogen- and sulfur-bearing species. In this work, we present a detailed analysis of the NS^+ DR process, with a particular focus on the indirect mechanism mediated by Rydberg states of the neutral NS molecule. Utilizing a hybrid approach that combines semi-empirical modeling and multichannel quantum defect theory (MQDT), we simulate the electron energy-dependent cross section by incorporating contributions from multiple Rydberg series converging to the NS^+ ionization threshold. Each resonance is modeled via the Breit–Wigner formalism, accounting for capture widths, predissociation rates, and autoionization lifetimes. Recent experimental findings on the Rydberg structure of NS are integrated to refine quantum defect parameters and validate energy level placements. Our results highlight the dominant role of low-lying Rydberg resonances in enhancing the DR cross section at sub-electronvolt energies, underscoring their significance in both astrophysical and controlled plasma environments. The implications of this study extend to improved kinetic models in molecular clouds and reactive plasma simulations.

Keywords: dissociative recombination, Rydberg states, Breit–Wigner resonance, quantum defect theory, interstellar chemistry, plasma kinetics, electron–molecule collisions.