Rovibrational transitions in HCl due to collisions with H_2: spin-free and hyperfine-resolved transitions

D. Hoffman,[1] J. Taylor,[1] T. J. Price,[1,2] Robert C. Forrey,[2] B. H. Yang,[3] P. C. Stancil,[3] Z. E. Zhang,[4] and N. Balakrishnan[5]

[1]*Department of Physics, Penn State University, United States*
[2]*Department of Mathematics and Technology, Alvernia University, United States*
[3]*Department of Physics and Astronomy, University of Georgia, United States*
[4]*Star and Planet Formation Lab, RIKEN, Japan*
[5]*Department of Chemistry and Biochemistry, University of Nevada, United States*

Hydrogen chloride (HCl) is a key repository of chlorine in the interstellar medium. Accurate determinations of its abundance is critical to assessing the chlorine elemental abundance and constraining stellar nucleosynthesis models. To aid in modeling recent and future observations of HCl rovibrational spectra, we present cross sections and rate coefficients for collisions between HCl and molecular hydrogen. Transitions between rovibrational states of HCl are considered for temperatures ranging from 10 to 3000 K. Cross sections are computed using a full dimensional quantum close-coupling (CC) method and a reduced dimensionality coupled-states (CS) approach. The CS results, benchmarked against the CC results, are used with a recoupling approach to calculate hyperfine-resolved rate coefficients for rovibrational transitions of HCl induced by H_2. The rate coefficients will allow for a better determination of the HCl abundance in the interstellar medium and an improved understanding of interstellar chlorine chemistry. We demonstrate the utility of the new rate coefficients in a non-thermodynamic equilibrium radiative transfer model applied to observations of HCl rovibrational transitions in a circumstellar envelope.