**Introduction**

With continual improvements in X-ray detector technology from charge-coupled devices (CCDs) to the reflection grating system (RGS) available on the current fleet of X-ray satellites (*Chandra, XMM-Newton, Suzaku*), the resolution of the X-ray lines have dramatically improved allowing for detailed studies of line formation mechanisms. While X-ray lines from highly ionized plasmas are primarily produced by electron impact excitation (EIE) in collisionally ionized equilibrium (CIE) or via electron radiative recombination (RR) in photoionized environments, a third mechanism, charge-exchange (CX) induced X-ray emission has been found to be important in situations where hot plasmas meet cold gas.

The importance of CX as an X-ray emission mechanism was recognized from studies of the Jovian aurora as early as the 1980s (e.g., Cravens et al. 1995, and references therein), but it was the detection of cometary X-ray emission (Lisse et al. 1996), and later its possible contribution to the soft X-ray background (SXB; Cox 1998; Cravens 2000) which brought CX induced emission to the attention of the high-energy astrophysics community. More recently, CX has been invoked for a host of environments, from supernova remnants (Katsuda et al. 2011; Cumbee et al. 2014) to extragalactic cooling flows (Fabian et al. 2011), in attempts to explain “anomalous” X-ray emission features which are unlikely to be attributable to EIE or RR. Unfortunately, the CX cross sectional data are of insufficient reliability or availability to allow for quantitative spectroscopic models. To partially address this situation, cross sections, as a function of kinetic energy, for a series of single electron capture (SEC) collision systems are calculated here using the multi-channel Landau-Zener (MCLZ) method (Janev et al. 1983; Butler & Dalgarno 1980), and the Molecular Orbital Close-Coupling (MOCC) method (Bransden and McDowell). The current computational study involves collisions of a range of highly charged Ne, Mg, and Fe ions with neutral H and He. In the vast majority of cases, explicit experimental or theoretical CX data are lacking. For this study, the MCLZ method was chosen since it is reasonably accurate for kinetic energies ≤10 keV/u. Since the computational effort is minimal, its adoption allowed us to investigate 17 collision systems benchmarking the results to other data when available. In addition, X-ray spectra and X-ray line ratios were determined for the case of an optically thin plasma under single collision event conditions. Also, the MOCC method was used for collisions.

In the next chapter, we briefly describe the theoretical approach adopted here, while Chapter 3 gives the resulting cross sections. Comparison is made to existing data when available with an emphasis on -resolved cross sections. Conclusions are given in Section 4. An Appendix discusses the implementation of the MCLZ method in a new computational package, *Stueckelberg*. Atomic units are used unless otherwise indicated.