THE THEORY OF RESONANT TRANSFER EXCITATION IN ION-ATOM COLLISIONS

Thesis

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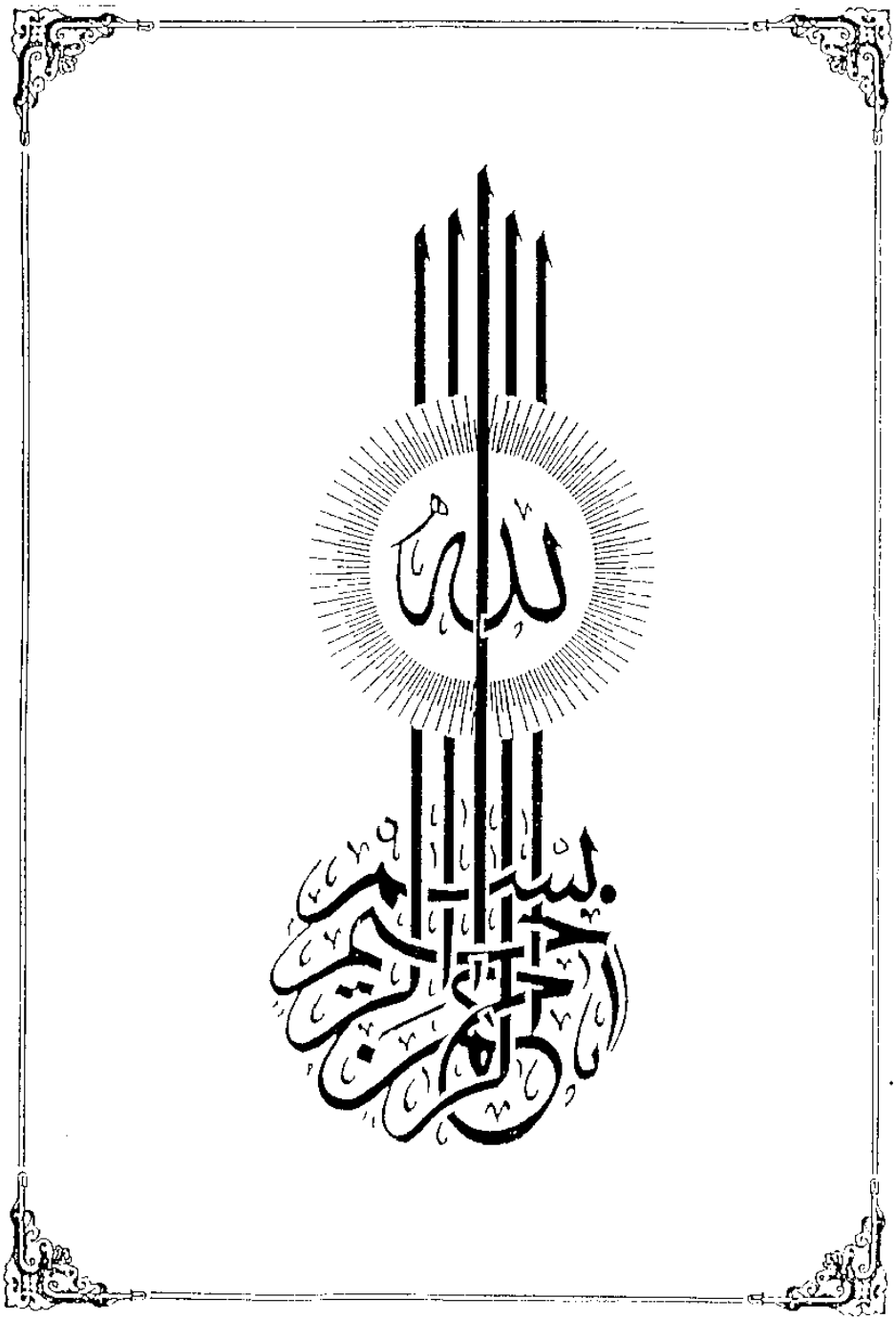

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ABSTRACT

RTEX cross sections are calculated for the collision of $Ca^{16+,17+,18+}$ ions with He and H_2 with K-shell excitation and found in agreement with experimental and theoretical data (Badnell 1990). In addition, RTEX cross sections are carried out for C-like S^{10+}, Ca^{14+}, Fe^{20+} with K-shell excitation. The isoelectronic trends of RTEX for C-like ions are discussed. Finally, the RTEX cross sections are calculated for $Fe^{20+,18+,17+}$ with both K- and L-shell excitations. The isonuclear trends of RTEX for Fe-isonuclear sequence are discussed and explained. RTEX cross sections for L-shell excitation are huge relative to the K-shell excitations. Thus, RTEX process manifests itself as a more efficient mechanism for outer shell excitation.

CHAPTER 1

INTRODUCTION

CHAPTER I

INTRODUCTION

In astrophysical and laboratory plasmas, various atomic processes are taking place, for example: electron-electron, electron-ion, and ion-atom collisions.

The resonant transfer excitation folllowed by X-rays (RTEX) in ion-atom (I/A) collisions is a process of much interest in the current research, experimentally and theoretically, since the last decade. It proceeds through the formation of doubly-excited resonance intermediate states which may be stabilized also by emission of Auger electrons (RTEA). Thus, RTEX and RTEA are two complementary processes in I/A collisions.

The RTEX process that occurs in I-A collisions, is a similar process to the dielectronic recombination (DR) in electron-ion (e-I) collisions. When the conditions of the impulse approximation are satisfied for I/A collisions, the RTEX and DR cross sections are related. Hence, RTEX cross sections are considered as indirect measurements for the DR cross sections. In addition, RTEX is successfull in the explanation of the theoretical DR cross sections especially those with small values for $\Delta n \neq 0$ transitions, where Δn is the change in the principal quantum number n. Moreover, RTEX is still the main source of experimental data for DR in highly charged ions.

The DR process is an important recombination mechanism that affects the ionization balance of plasmas and is of interest in plasma diagnostics. The emission of X-rays in both RTEX and DR causes the self-cooling of plasmas which make them of special interest in theoretical and experimental studies each in its own right and through their relationship.

The relationship between DR and RTEX processes has been formualted by Brandt (1983) and verified theoretically by MacLaughlin and Hahn (1984, 1985), Omar and Hahn (1987), Hahn et al (1987), Hahn and LaGattuta (1988), Badnell (1990, 1993) and Omar (1992). This was in parallel to the experimental work by Tanis et al (1982, 1984, 1985, 1986), Bernstein et al (1986, 1987, 1989), Reusch et al (1988), Graham et al (1986) Schonfeldt et al (1987) for measuring the RTEX cross sections. Also, very recent experiments were carried out for measuring the DR cross sections by Dewitt et al (1991, 1992, 1993) and Knapp et al (1993) which invoked the theoretical work on heavy ions.

The intensive and extensive experimental and theoretical works on RTEX and DR processes in parallel to the other atomic processes such as ionization and excitation are still continuing to improve the knowledge and understanding of the factors affecting the time rate of change of the number of ions in a plasma. This, when completed, will bring the plasma energy to the field of reality.

Unfortunately, there is a gap in the available theoretical data for B-like up to F-like ions in RTEX and DR cross sections.