CONF-790861--1

Introduction of Symposium
To be in the "Invited Lectures" of XI ICPEAC, Kyoto, August 29, 1979

INTRODUCTORY REMARKS ON ELECTRON CAPTURE BY MULTICHARGED IONS*

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Electron capture has been one of the most widely studied atomic collision processes. Capture either controls or plays an important part in the evolution of many physical systems, and it has proven to be one of the most difficult of basic collision processes to predict reliably. Capture by multicharged ions has some unique aspects and is of applied importance, so it is surprising that there were few reported results for the most important low velocity regime until 1975. A significant amount of experimental and theoretical work on this subject has appeared in the short time since then, and it is a distinct pleasure to be able to introduce this Symposium, which I hope will review those recent developments, indicate present research endeavors, and allow international review of the subject area.

The Symposium will be somewhat more narrow in scope than indicated by its title. We will concentrate on collision velocities less than 4×10^8 cm/s, where the capture cross sections are largest and where most of the available results are quite recent. We plan to deal primarily with those capture processes that have the largest cross sections and are of most direct applied interest. For the Symposium we have generally taken "multiply charged" to mean initial charge 3+ or greater. One of the important, unique features of multicharged-ion capture is the dominance of capture into excited states, and a significant part of this Symposium is dedicated to the experiments attempting to measure capture to excited states. I apologize to anyone who feels his research is not properly represented in the Symposium. There are some interesting new results that did not get included, and I believe that anyone interested in this Symposium should also be interested in the poster sessions on multicharged-ion electron capture described on pp. 57-59 of the "3rd Notice and Conference Program," and the abstracts of these sessions on pp. 556-608 of the "Book of Abstracts of Contributed Papers of ICPEAC."

Table I presents an overview of applications of multicharged-ion electron capture and, through the qualitative assessment of availablility of information, presents the general status of our understanding of such capture. The table may not be complete and represents a subjective overview. However, it is true that fusion and astrophysics are major applied areas requiring data on multicharged-ion electron capture, and it is true that atomic hydrogen (deuterium) is the most important target both for comparison of theory and experiments and for direct applied needs. While theory has supplied some information relevant to all of the applied needs, it is still evolving - determining best approximations and assessing reliability. In the velocity range 4×10^7 to 4×10^8 cm/s, some recent success in the form of agreement of theory and experiment has been achieved for specific ions colliding with atomic hydrogen, which Dr. Olson will discuss. Beyond these specific cases with good agreement, there are now enough experimental and theoretical total capture results in this energy range to allow some generalizations, and Dr. Salzborn and Dr. Ryufuku will present these.

DISCLAIMER

Table I. Applications of Electron Capture by Multicharged Ions at Low Velocity

Application	Needs				Availability		
	Process	Energy keV/amu	Ions	Target	Exp.	Theor.	Confidence
Fusion							
Injection D^0	Total Capture Ionization Excited States	15-500 " " " "	C, O, Fe, Ti, High q	H(D)	S I N	S* S S	30-50% x2 50% to x2
Recycle imp. and refuel H_2 gas	Total Capture Excited States	0-1 " "	C, O, Fe, Ti, Low q	H(D)	N N	I I	x10 x10
Plasma Cooling	Total Capture (Recombination) Excited States	0.1-10 " "	C, O, Fe, Ti High q	H(D)	I N	S S	30% to x2 x2
Diagnostics	Excited States	0.1-10	" "	H(D)	N	S	x2
Heavy ion beam fusion	Total Capture Ionization	0.1 to 100	Examples, Hg^{3+}, Ba^+	Hg^{3+} Ba^+	I	S	x2
Astrophysics							
Interstellar Medium	Total Capture (Recombination)	~ .001	C, N, O, Fe Low q	H (H_2, He)	N	I	x10
Corona	Excited States (Astronomy)	0-10	" "	H (H_2, He)	N	S	x2 to x10
Ion Production	Total Capture (In Source)	~ 0.1	All	N_2, H_2	I	I	x2
	Excited States (Diagnostics)	0-5		Source Gases	I	I	x2
Ion Transport	Total Capture Ionization	0.1 to 5000	All	N_2, H_2 H_2O Rare Gas	S	S	30% to x2
Short Wavelength Lasers	Excited States (Pumping)	~ 1	Any	Any	I	I	x2

*S = some information, I = incomplete, N = none, x2 = uncertain by factor of two

According to Table I there are no experimental results on excited state formation, but this is true only for the atomic hydrogen target. Some interesting experimental results on excited state formation during capture have been produced for rare gas targets, and these will be presented by Dr. de Heer and Dr. Panov. Especially for nonhydrogen targets, collisions involving more than one electron are observed; examples are multiple electron capture or capture with excitation of the target. For these types of events, experimental results can lead the way in providing new problems for theory, which has concentrated on single electron descriptions.

The least understood region is for velocities below 10^7 cm/s. Here virtually no experimental results exist, but theory is stimulating our imaginations with predictions which vary by orders of magnitude depending on the specific system. Dr. McCarroll will briefly present a recent calculation which is typical of these results, and it is hoped that experimental tests will be forthcoming.

In spite of the fact, as Table I shows, that a great deal of experimental work yet remains, most of the easy experiments have already been done. The surge of new results since 1975 was made possible by ion source development (mostly ion sources for cyclotrons). Continuing ion source development will access higher charge states at low velocities, but studies at very low velocity ($v < 10^7$ cm/s) and studies on state-specific products of capture with hydrogen target will require technical advances in experimentation, not just better ion sources. Such experimental advances are in progress, and the future should continue to produce exciting new results.

*Research sponsored by the Office of Basic Energy Sciences, U. S. Department of Energy, under contract W-7405-eng-26 with the Union Carbide Corporation.