Superelastic Electron Scattering from Caesium

Daniel Slaughter, B.Sc. (Hons.)

School of Chemistry, Physics and Earth Sciences,
Faculty of Science and Engineering,
Flinders University

May, 2007

Summary

This thesis describes an experimental study of superelastic electron scattering from the $6^2P_{3/2}$ state of caesium. The present status of electron-atom collision studies is initially reviewed and the motivation behind the current work is then presented. A description of the theoretical framework is subsequently provided in the context of the present experimental study, followed by an overview of the several theoretical approaches for describing electron-atom interactions which are currently available.

The apparatus and experimental setup used throughout the project are also described in detail. Technical specifications and data are provided, including diagrams (where appropriate) for a laser frequency locking system, electron gun and spectrometer, atomic beam source and data acquisition system. The experimental procedures are explained and discussed, including a detailed analysis of the optical pumping process required to excite the atomic target. A substantial component of this project was to address several potential sources of systematic error and to reduce these wherever possible. All of the errors and uncertainties relevant to the experiment are discussed in chapter 5.

In chapter 6 the results of the present superelastic electron scattering experiments are reported for incident electron energies of 5.5eV, 8.5eV and 13.5eV, corresponding to superelastic electron energies of 7eV, 10eV and 15eV. These results are presented as three reduced Stokes parameters, $\overline{P}_1$, $\overline{P}_2$, $\overline{P}_3$ and a coherence parameter, P^+. For comparison, predictions from a number of currently available theories are presented

alongside the experimental results. Finally, conclusions are drawn on this work in the context of the current status of electron-atom scattering from alkali-metals.

Declaration

I certify that this thesis does not incorporate without acknowledgement any material previously submitted for a degree or diploma in any university; and that to the best of my knowledge and belief it does not contain any material previously published or written by another author except where due reference is made in the text.

Daniel Stephen Slaughter

Acknowledgements

The work described in this thesis would not have been possible without the help of many of my family, friends and colleagues. Firstly I must thank my supervisors, Prof. Peter Teubner and A/Prof. Michael Brunger. Peter has been more than a supervisor to me: a mentor, a friend and a steadfast source of helpful, sound advice. His understanding and guidance throughout my studies at Flinders University were invaluable and will never be forgotten. My thanks and appreciation are also extended to Michael, who has always welcomed our discussions with kind suggestions and friendly guidance. I could not have completed this work without his support.

My warm gratitude goes to Dr. Victor Karaganov, for his expert assistance and advice in the laboratory and for the many helpful discussions we had in the early stages of this project.

To the Mechanical and Electronics Workshops, go my sincere thanks. In particular I acknowledge Bob Northeast, Bob deVries, John Pesor, Greg Hewitt, Mike Mellows and Bruce Gilbert, who together were responsible for the building of a large part of the apparatus used in this project. This thesis would not have been possible without their skills and expertise in maintaining the apparatus, along with their many helpful discussions and ideas along the way.

Of course I also wish to mention my immediate family, Mum, Dad, and Jessica, and the many friends who have never failed to lend their support. Their boundless enthusiasm and encouragement has and will always continue to be a source of inspiration to me.

Finally, the Ferry Trust is gratefully acknowledged for providing me with financial assistance during my candidature.