A.2.2. Inelastic Scattering of Electrons from Ions--*Patrick Richard and Chander Bhalla*

Doubly excited resonance states can be seen in the inelastic electron scattering cross section when their total excitation energy exceeds the energy for a free electron plus an excited state of the ion. This is the case, for example, for the 3P3P' doubly excited states of two electron ions as depicted in Fig. 4 in Sec. A.2.1. The doubly excited states can decay by electron emission to the 1s ground state (i.e. the elastic scattering channel) or the 2P first excited state (i.e. the inelastic scattering channel) of the ion and by x-ray emission to the 1s3P' state (i.e. the DR channel). Although, the direct inelastic scattering cannot be easily separated from the cusp continuum created in ion-atom scattering, the doubly excited resonance states are prominent enough to be easily measured above the cusp continuum as pointed out by Hvelplund *et al.* [1]. Absolute cross sections for resonant inelastic $e^- + O^{7+}$ scattering have been reported by Toth *et al*. [2] and Grabbe *et al*. [3, see Publication #17] for 180° scattering in the center of mass as observed at 0° in the laboratory electron emission spectrum. Zavodzsky *et al*. [4, see Publication #82] recently observed a backward-forward asymmetry in the decay of the 3P3P' resonances in the electron-F^{8+} DCS by looking at the electron peaks above and below the cusp energy. From the electron emission kinematics, a low energy electron emitted from a fast ion can be observed at two energies in the laboratory frame. For an Auger electron of some energy E in the center of mass, there is one Auger electron peak at 0° in the lab frame above the cusp energy (180° electron scattering in the projectile frame) and one peak below the cusp energy (0^o electron scattering in the projectile frame). The electron emission spectrum containing the 3PnP' series of F^{7+} is shown in Fig. 1. The extracted electron inelastic DCS for $e^- + F^{8+}(1s) \rightarrow F^{7+}(3P3P') \rightarrow e^- + F^{8+}(2P)$ is shown in Fig. 2, together with a comparison to a close coupling R-matrix calculation. The upper figure contains the DCS for 180° scattering in the cm, and the lower figure contains the DCS for 0° scattering in the cm. Many 3P3P' discrete doubly excited resonances are observed in the experiment and the theory predicts the shape and detail of the observed DCS exceedingly well.

As in the case of the elastic scattering resonances, no DCS for inelastic resonance scattering of electrons on highly charged ions, using the electron-ion merged or crossed beams method, have been reported in the literature.

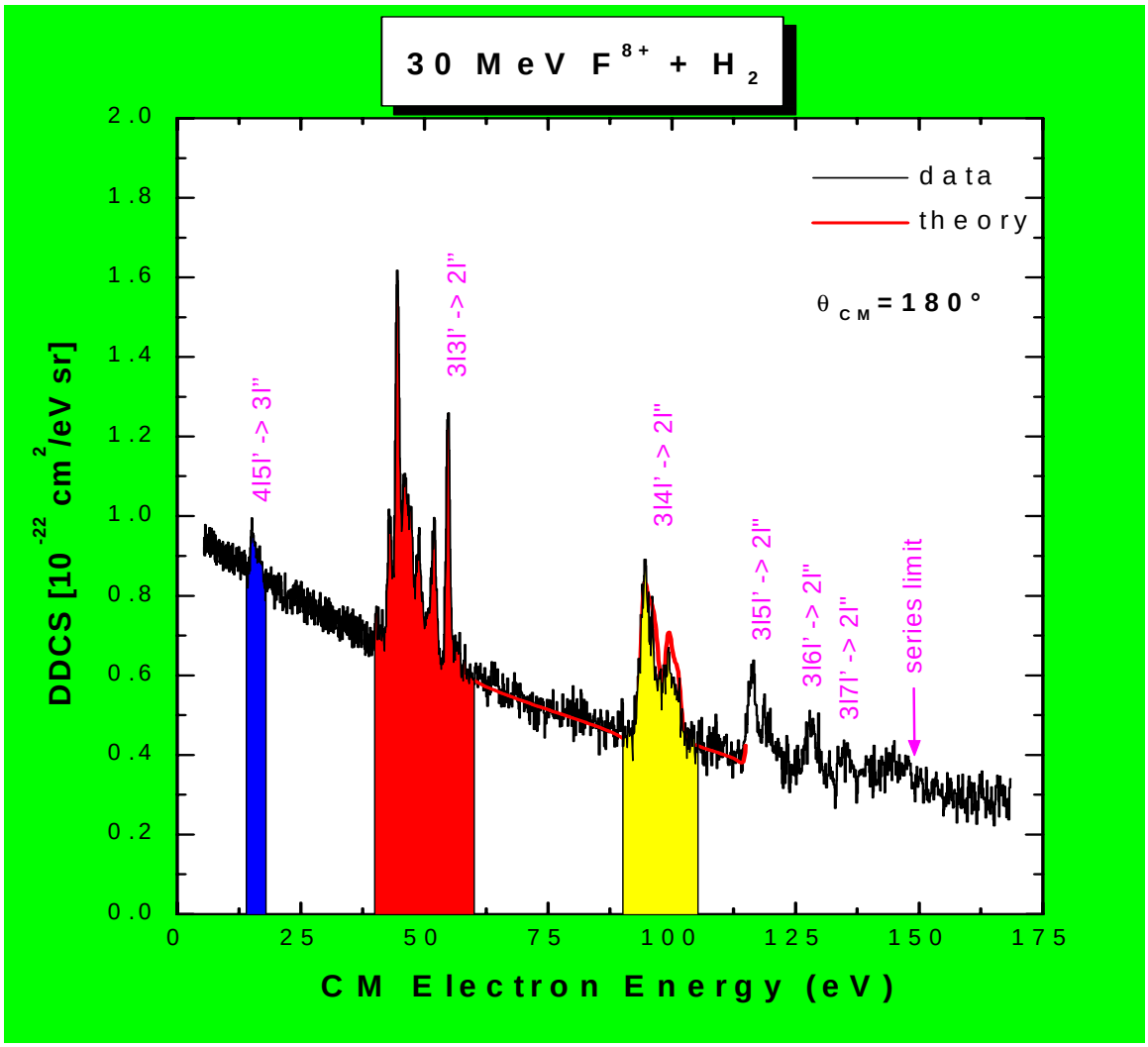

Figure 1. DDCS for the 1s → 2P inelastic scattering via the F^{7+}(3PnP') resonances in the F^{8+} + e^- system.

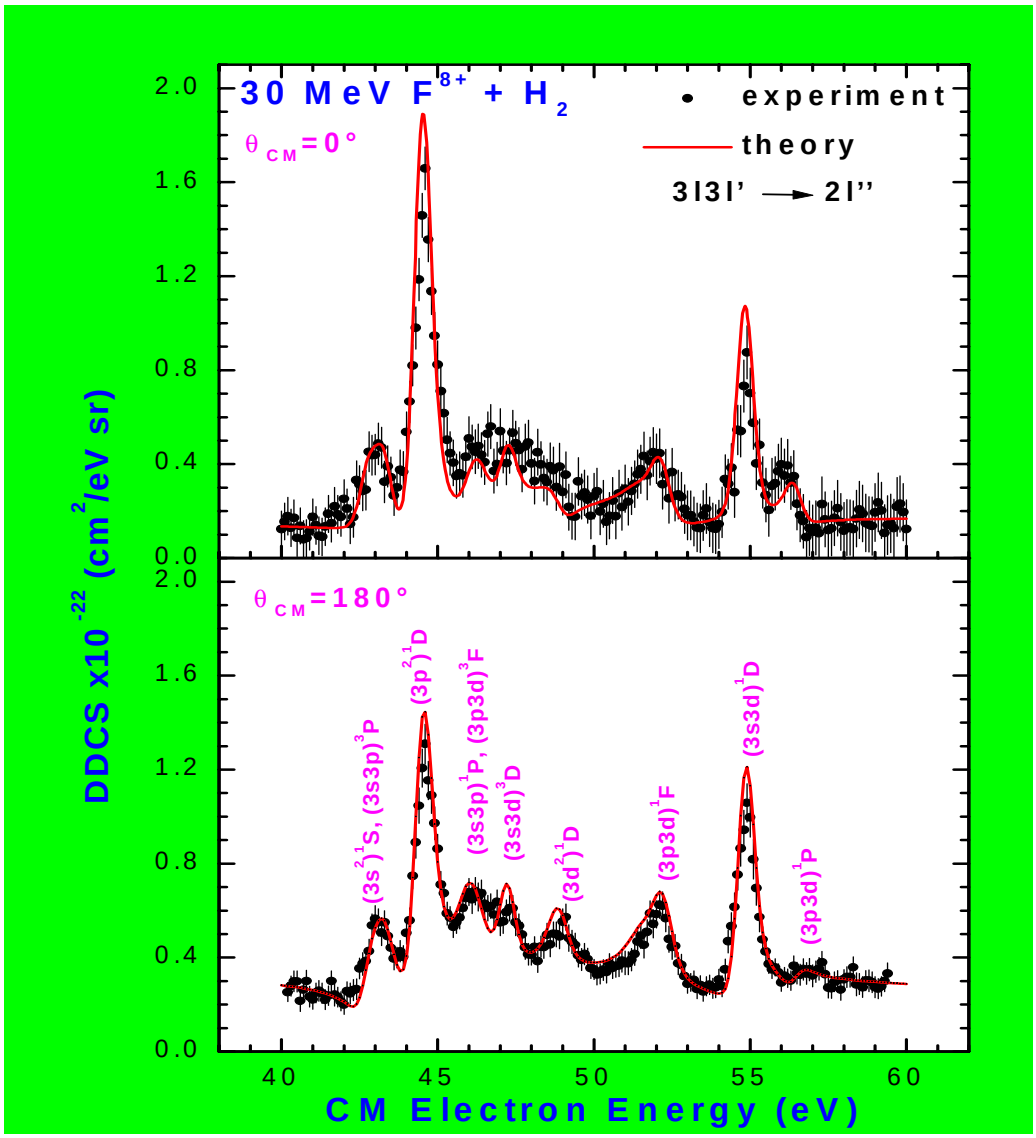

Figure 2. DDCS for 3P3P' resonances in F^{7+} at 0° (upper figure) in the cm and at 180° (lower figure) in the cm.

(P.A. Zavodszky, H. Aliabadi, G. Toth, S.R. Grabbe, T.J.M. Zouros, J.A. Tanis, C.P. Bhalla, and P. Richard collaborated on this research project.)

Publications Related to Inelastic Scattering of Electrons from Ions:

Publ. #16: "Production of the O^{5+}(1s2s2p, ^4P_J) States by Electron Excitation in 10-34 MeV Collisions of O^{5+} Ions with H_2, He, Ne, Ar, Kr and Xe Targets," by Toth, *et al.*

Publ. #17: "Elastic and Inelastic Scattering Models in Ion-Atom Collisions" by Grabbe, *et al.*

Publ. #66: "Quasi-free Electron-Ion Scattering in Ion-Atom Collisions," by Richard, *et al.*

Publ.#68: "Resonant Two-Electron Processes in Ion-Atom Collisions," by Zavodszky, *et al.*

Publ. #82: "Forward-Backward Asymmetry in the Inelastic Scattering of Electrons from Highly Charged Ions," by Zavodszky, *et al.*

References

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2. G. Toth, S. Grabbe, P. Richard, and C.P. Bhalla, Phys. Rev. A 54, R4613 (1996).
3. S.R. Grabbe, G. Toth, C.P. Bhalla, and P. Richard, Nucl. Instrum. and Methods in Physics Research B 124, 347 (1997).
4. P.A. Zavodszky, *et al.*, J. Phys. B: At. Mol. Opt. Phys. 32**,** 4425 (1999).