A.2.3. Superelastic Scattering of Electrons from Metastable Ions--*Patrick Richard and Chander Bhalla*

We recently performed an experiment where the superelastic scattering of electrons from ions has been observed by the use of the ion-atom collision technique. Superelastic scattering of electrons can occur by scattering electrons from a metastable ion beam. This process is the inverse of inelastic scattering and gets its name from the fact that the outgoing electron has more energy than the incoming electron. Direct electron superelastic scattering has been observed for atoms and ions with very low states of excitation [1], but it has not been observed for inner shell excitation of highly charged ions. Figure 1 contains the energetics for superelastic scattering of electrons from the 1s2s ^{3}S state of F^{7+} to the ground state of F^{7+}. It is the inverse of the process labeled direct inelastic scattering in Fig. 4 in Section A.2.1. For comparison, the competing processes of resonant elastic and resonant superelastic scattering are indicated. The resonant elastic scattering from metastable ions leads to triply excited hollow ionic states, which is discussed in A.2.4. Resonant superelastic scattering from metastable ions is a very weak process and has not been observed to date. Figure 2 shows the result of the experiment by Zavodzsky, *et al.* [2, see references #66 and #68]. The observed superelastic scattering peak is obtained by subtracting the F^{6+} DDCS modified by the F^{6+}:F^{7+} DDCS enhancement factor from the F^{7+} DDCS. The solid line is an ESM calculation of the superelastic scattering cross section multiplied by the metastable beam fraction. Nearly perfect agreement is found, however there is an ~ 30 % uncertainty in the observed cross section due to the low statistics and the subtraction procedure. This observation gives another example of the power of the ion-atom collision method in the study of electron-ion collision processes not possible to date by direct electron-ion collision techniques.

(P. A. Zavodszky, G. Toth, H. Aliabadi, J. A. Tanis, C. P. Bhalla, and P. Richard collaborated on this research project.)

<u>Publications Related to Superelastic Scattering of Electrons from Ions</u>:

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.*

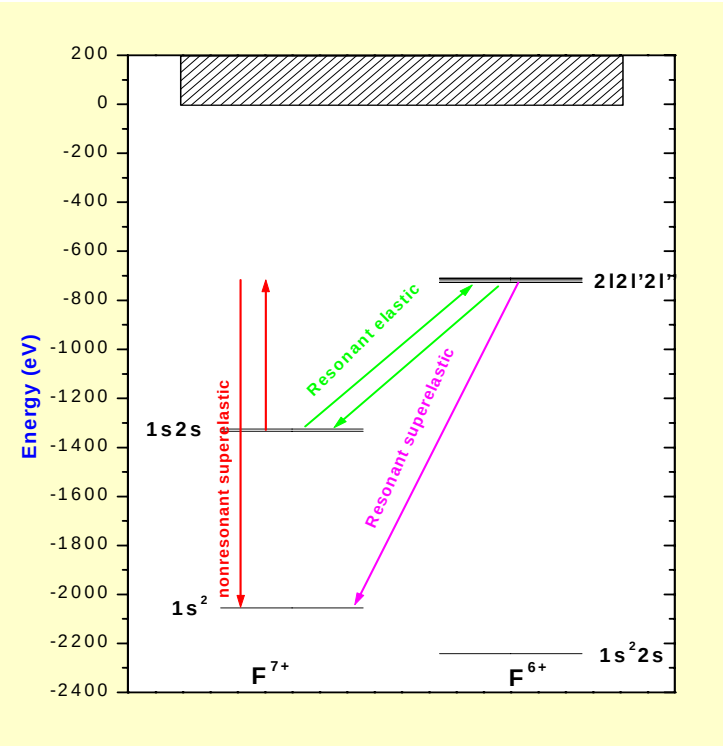

Figure 1. Energetics of the F^{6+} complex showing the nonresonant and resonant superelastic scattering channels and the resonant elastic scattering channel for F^{7+}(1s2s)+e interactions. The non-resonant superelastic scattering channel is observed in this work, but not the resonant superelastic scattering channel, which would give rise to triply-excited states in the superelastic scattering spectrum. The triply-excited states are observed in resonant elastic scattering channel (see Sec. A.2.4).

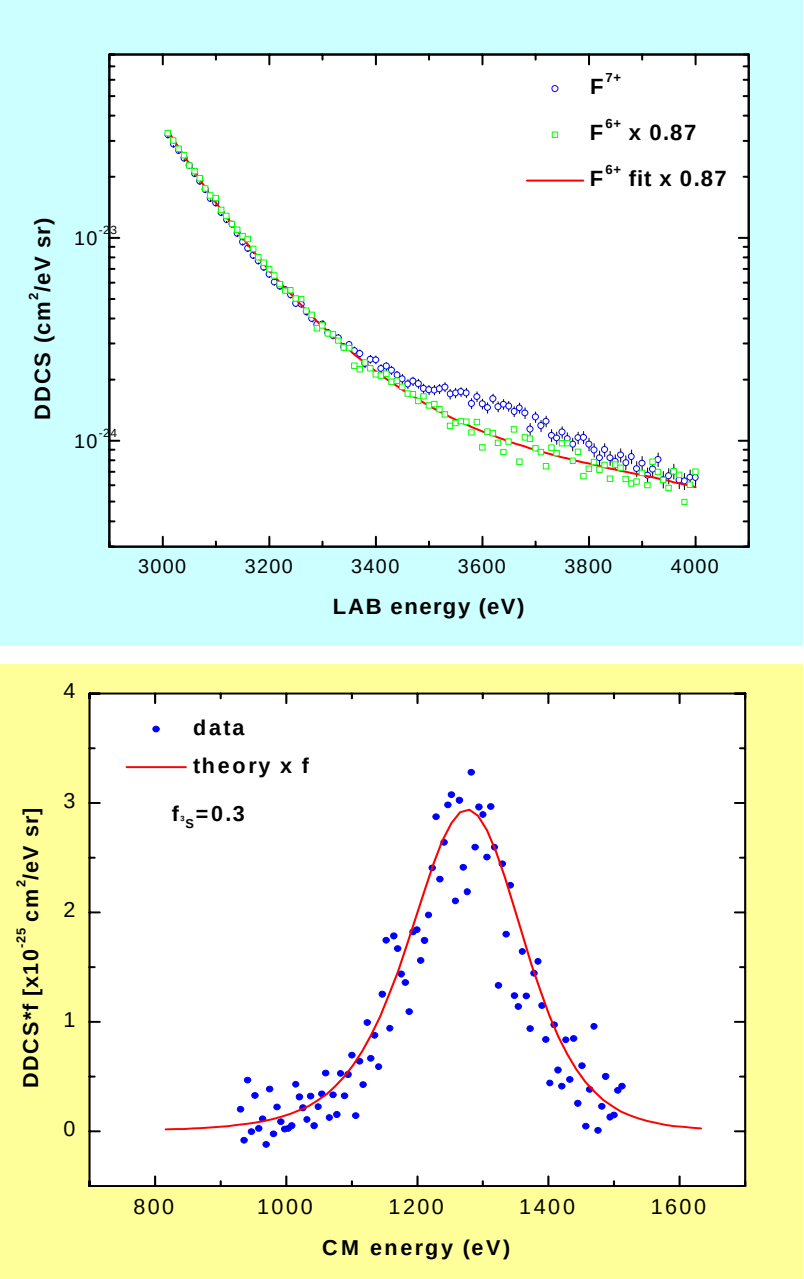

Figure 2. Superelastic scattering of quasi-free electrons in F^{7+*} + H_2 collisions. DDCS for F^{6+} and F^{7+} + H_2 collisions (upper half); F^{7+*} + e 2P Ψ 1s superelastic scattering (lower half).

References

1. I.D. Williams, Physica Scripta T 73, 121 (1997).
2. P.A. Zavodszky, *et al.*, to be published.