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Autodetaching state of F^- and autoionizing states of F†

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The collisional excitation method is used to excite an autodetaching state of F^- and several autoionizing states of neutral F. The F^- state lies at 14.85 ± 0.04 eV above the neutral-fluorine ground state and has as its dominant configuration $2p^4(^1D)3s^2\,^1D$. The observed autoionizing states of fluorine have configurations $(^1D)nl'$ and $(^1S)nl''$.

In two recent papers[1,2] we reported measurements on autodetaching states of O^- and Cl^- and autoionizing states of O. The same apparatus and procedure has been used to observe the autoionizing states of neutral fluorine and an autodetaching state of F^-.

An F^- ion beam is extracted from a duoplasmatron, accelerated, momentum analyzed by a magnet, and focussed into a differentially pumped chamber containing helium. The electrons ejected from the region of the F^- on He collisions are energy analyzed to obtain an electron spectrum. The electron spectrum consists of a smoothly varying background due to electrons stripped from the ion beam plus peaks due to electrons ejected from autodetaching states excited in the collisions. Such a peak appears in the spectrum shown in Fig. 1 corresponding to an F^- autodetaching transition at 14.85 ± 0.04 eV. Calculations by Matese *et al.*[3]

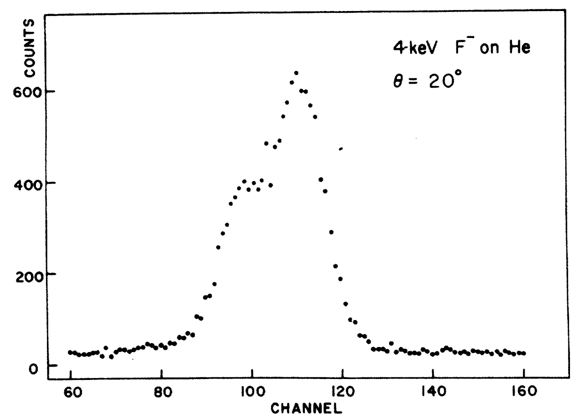

FIG. 1. Electron spectrum produced by collisions of 4-keV F^- on He. The doublet structure is due to the splitting of the neutral fluorine $^2P_{3/2,1/2}$ ground-state term. Each channel corresponds to approximately 4 meV.

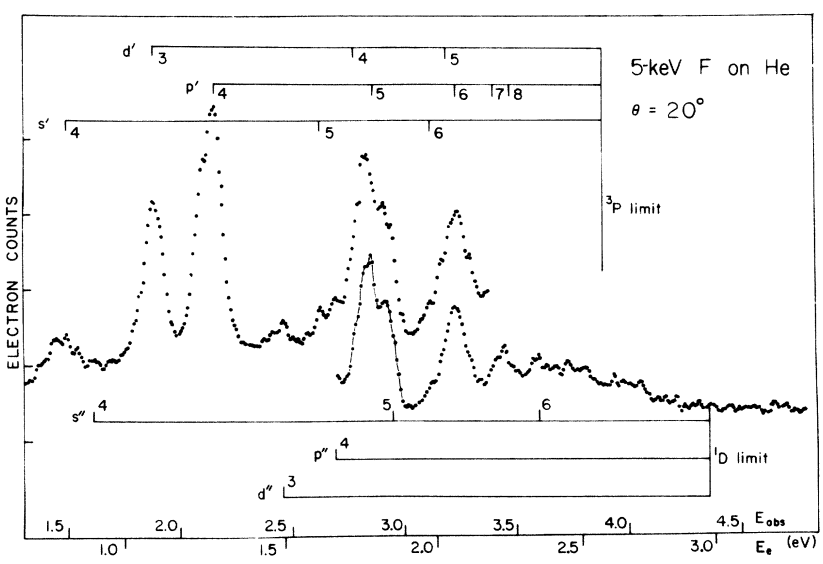

FIG. 2. Electron spectrum produced by collisions of 5-keV neutral F on He. E_{obs} is the transition energy measured in the laboratory frame and E_e is the transition energy in the frame of the neutral-fluorine atom.

TABLE I. Autoionizing levels of fluorine. The energies are measured with respect to the $^2P_{3/2}$ ground state of the neutral fluorine atom.

Fluorine level	Huffman *et al.* [a] (eV)	Present work (eV) ±0.05 eV
$(^1D)\,4s'\ ^2D$	18.184	18.18
$5s'$	19.035	19.02
$6s'$	19.404	19.42
$(^1D)\,4p'$		18.66
$5p'$		Unresolved
$6p'$		19.50
$(^1D)\,3d'$	18.466	18.48
	18.489	
$4d'$	19.145	Unresolved
	19.155	
$(^1S)\,4s''\ ^2S$		20.88
$5s''$		Unresolved
$6s''$		22.37
$(^1S)\,3p''\ ^2P$		20.11
$4p''$		21.67
$(^1S)\,3d''\ ^2D$		21.50

[a] Reference 4.

predict the $2p^4(^1D)3s^2\ ^1D$ F^- state to be at 14.85 eV. The structure in the peak is due to the fluorine ^2P ground-state splitting of 0.05 eV. More structure in the electron spectrum occurs about $\frac{1}{2}$ eV lower in energy; however, its position is too uncertain to attempt identification with another F^- state.

In order to observe the autoionizing states of neutral fluorine, a stripping cell is placed directly in front of the collision chamber to form a beam of F atoms. The electron spectrum from collisions of neutral F with helium is measured. Figure 2 shows a typical spectrum. The energy scale is calibrated using the $(^1D)3d'$ state as measured by Huffman and co-workers[4] in a photoabsorption experiment. They were able to resolve two terms for this configuration. Our resolution was not good enough to separate the terms, so a mean value for the two was used. For the states with the configuration $(^1D)nl'$ the transition was into the $F^+(^3P)$ continuum, and for the $(^1S)nl''$ configurations it was into the $F^+(^1D)$ continuum. The energies of the autoionizing levels are listed in Table I.

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[1]A. K. Edwards and D. L. Cunningham, Phys. Rev. A 8, 168 (1973).

[2]D. L. Cunningham and A. K. Edwards, Phys. Rev. A 8, 2960 (1973).

[3]John J. Matese, Steven P. Rountree, and Ronald J. W. Henry (unpublished). We thank Dr. Henry for the results of these calculations prior to publication.

[4]R. E. Huffman (private communcation). We are indebted to Dr. Huffman for communicating these results to us prior to publication.