PHOTOIONIZATION OF ATOMIC IODINE AND ATOMIC TELLURIUM

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Using a thermal atomic beam source and photoionization mass spectrometry, we have obtained the photoionization yield curve of atomic iodine from $\sim 645 \text{ \AA}$ to the ionization threshold. A portion of this spectrum appears in Fig. 1. We have observed most of the features that appeared in the photographic absorption work of Huffman, et al.⁽¹⁾ Our threshold and convergence limit energies differ slightly from theirs. Many, but not all, of the allowed Rydberg series can be seen. Those series identified as Rydberg d-like have quantum defects of $\sim 0.3 - 0.4$ (modulo 1), $q \approx 1$ and are relatively intense. Others identified as Rydberg s-like series have quantum defects of ~ 0 and are sharp peaks. We have verified the higher ionization energy for $1S_0$ given by Huffman et al., which differs significantly from the value given in Moore's tables.⁽²⁾

A thermal source generating atomic tellurium has been used to obtain the photoionization yield curve of Te between $\sim 670 \text{ \AA}$ and the ionization threshold.

Figure 1. A segment of the ion yield curve in the photoionization of atomic iodine, displaying autoionization features converging to $1D_2$ of I^+ .

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Figure 2. A segment of the ion yield curve in the photoionization of atomic tellurium, showing autoionization features converging to $2D_{3/2}$ and $2D_{5/2}$ of Te^+ .

A section of this spectrum is displayed in Fig. 2. Upon analysis, this spectrum reveals some similarities to that of iodine (and indeed, that of xenon) in that the Rydberg d-like excitations are relatively intense, have quantum defects ~ 0.3 and $q \approx 1$. The inner 5s orbital excitations have been observed, and display window resonances similar to those in the noble gases. When account is taken of the difference in excitation energies between initial $3P_2$ and $1S_0$ states, no visible correlation is seen between our autoionization pattern for Te and that calculated by McGuire.⁽³⁾ McGuire's calculations lead him to question the ionization energy given by Moore,⁽²⁾ but the present results are in good agreement with all of the ionic energies for Te^+ listed by Moore and encompassed by our data.

Finally, we shall try to make some comparisons between the present results on iodine and the two calculations that have incorporated resonance features on the related chlorine atom. Both the R-matrix⁽⁴⁾ and many body perturbation theory⁽⁵⁾ calculations deduce a strong Rydberg d-like series converging to $1D_2$, and having an anomalous resonance profile. Lamoureux and Combet Farnoux⁽⁴⁾ calculate $q \approx 3.6$ for this resonance, probably somewhat higher than the value we would estimate for iodine, but generally a similar shape with minimum preceding maximum. Also comparable is one series of resonances converging to $1S_0$. This one series consists of peaks superposed upon continuum (relatively high q) and is obtained in both calculations. The R-matrix calculations display a much larger peak to continuum ratio than do the many body perturbation theory results. The iodine data look rather like the latter. Brown, et al.⁽⁵⁾ also

calculate window resonance features for the inner s excitations of chlorine. While we have not observed these for iodine, we do see them in tellurium.

Hence, despite the complexities introduced by the many series that become allowed with open shell atoms, some patterns have begun to emerge.

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