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CORRELATION OF RESONANCE CHARGE EXCHANGE CROSS-SECTION DATA IN THE LOW-ENERGY RANGE

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During the course of a literature survey concerning resonance charge exchange, an unusual degree of agreement was noted between an extrapolation of the data reported by Kushnir, Palyukh, and Sena\(^1\) and the data reported by Ziegler.\(^2\) The data of Kushnir et al. are for ion-atom relative energies from 10 to 1000 ev, while the data of Ziegler are for a relative energy of about 1 ev.

Extrapolation of the data of Kushnir et al. was made in accordance with Holstein’s theory,\(^3\) which is a combination of time-dependent perturbation methods and classical orbit theory. The results of this theory may be discussed in terms of a critical impact parameter \(b_c\). For impact parameters less than \(b_c\), the theory says the probability of charge exchange \(P\) is a rapidly oscillating function of \(b\) with extremes at 0 and 1 and an average value of \(\frac{1}{2}\). For \(b > b_c\), \(P\) rapidly drops from \(\frac{1}{2}\) to zero with increasing \(b\). Holstein gives the expression for \(P\) as a function of \(b\) and relative energy \(\epsilon\). Setting \(P\) equal to \(\frac{1}{2}\), he gets an equation for all the \(b\)'s where \(P\) passes through \(\frac{1}{2}\). If attention is restricted to the largest \(b\), which is a solution to this expression, we have \(b_c\) as a function of energy. If \(b_c\) is used to compute a cross section \((\sigma = \pi b_c^2)\), Holstein's theory gives
a charge exchange cross-section energy relationship of the form,

$$\epsilon = K_1 \sigma^2 \exp(-K_2 \sigma^2),$$

where $K_1$ and $K_2$ are functions of the interaction potential. Note that, for a given $\epsilon$, $\sigma$ is double valued. The lower $\sigma$ value had no meaning as a cross section. It corresponds to one of the $b_i$'s less than $b_c$ where the oscillating $P$ passes through \( \frac{1}{2}. \) A curve of the form of the above equation was fitted to the data of Kushnir et al. These curves (corrected for polarization) are shown in Figs. 1 and 2 for Ar and Xe, respectively. The data of Ziegler are also shown in these figures.

The mobilities of Ar and Xe were computed according to Holstein using the extrapolated cross-section curves of Figs. 1 and 2. The computed values of mobility are compared in Table I with experimental values reported by Biondi and Chanin.

The agreement of the two sets of cross-section data with each other and with mobility data is unusually good when one considers the wide range of energy included in the correlation.

Table I. Mobility at 300°K.

<table>
<thead>
<tr>
<th></th>
<th>Mobility (cm²/volt-sec)</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Biondi and Chanin⁸ (experimental)</td>
</tr>
<tr>
<td>Ar</td>
<td>1.6</td>
</tr>
<tr>
<td>Xe</td>
<td>0.595</td>
</tr>
</tbody>
</table>

⁸See reference 4.
⁹See reference 1.