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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 and the data reported by Ziegler. 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, 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 $\frac{1}{4}$. 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 $\frac{1}{4}$, he gets an equation for all the $b$'s where $P$ passes through $\frac{1}{4}$. 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...
FIG. 1. Charge exchange cross-section for Ar\(^{+}\) in Ar. Curve is Eq. (1) fitted to data of Kushnir et al.

FIG. 2. Charge exchange cross-section for Xe\(^{+}\) in Xe. Curve is Eq. (1) fitted to data of Kushnir et al.

A charge exchange cross-section energy relationship of the form,

\[ \epsilon = K_1 \epsilon^{1/2} \exp(-K_2 \epsilon^{1/2}) , \]

where \( K_1 \) and \( K_2 \) are functions of the interaction potential. Note that, for a given \( \epsilon \), \( \alpha \) is double valued. The lower \( \alpha \) value had no meaning as a cross section. It corresponds to one of the \( b \)'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\(^c\)) 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\(^d\) 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.\(^e\)

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>
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<th>Mobility (cm(^2)/volt-sec)</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Biondi and Chanin(^a) (experimental)</td>
</tr>
<tr>
<td>Ar</td>
<td>1.6</td>
</tr>
<tr>
<td>Xe</td>
<td>0.595</td>
</tr>
</tbody>
</table>

\(^a\)See reference 4.  
\(^b\)See reference 1.

\(^c\)See reference 4.  
\(^d\)See reference 1.  
\(^e\)See reference 1.