Dielectronic recombination of Bi^{80+} and Bi^{82+}

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We have calculated dielectronic recombination (DR) cross sections for $\Delta n=0$ transitions in Li-like Bi using the semirelativistic version of the AUTOSTRUCTURE code. We present results for the full Rydberg series associated with the $2s\rightarrow2\bar{p}$ $(j=1/2)$ core excitation, which opens up at $n=20$ and spans only 16 Ry, compared to the series associated with the $2s\rightarrow2p$ $(j=3/2)$ excitation, which opens up at $n=6$ and spans 200 Ry. We have also calculated fully relativistic and semirelativistic *KLL* DR cross sections for H-like Bi and find the effect of the Breit interaction to be important.

Experimental dielectronic recombination (DR) cross sections for highly charged ions $(Z\geq80)$ should be emerging from heavy-ion sources and storage rings in the near future.[1] In fact, high-energy $(\Delta n=1)$ DR-type cross sections have already been measured[2] in $U^{90+}+H_2$ ion-atom collision experiments. Measurements of high-resolution low-energy $(\Delta n=0)$ DR cross sections will be possible with merged electron-ion beams. We have recently[3] presented results for the full Rydberg series associated with the $2s\rightarrow2p$ $(j=3/2)$ core excitation in U^{89+} and these span 350 Ry. We now present similar results for Bi^{80+} and find that they still span 200 Ry. We now also consider DR via the $2s\rightarrow2\bar{p}$ $(j=1/2)$ core excitation for which the full Rydberg series should be accessible with a relative electron-ion energy of 16 Ry in the rest frame of the ion. Returning to $\Delta n=1$ transitions, it has already been shown that the Breit interaction has a significant effect on the *KLL* resonances of He-like[3] and Li-like[4] uranium. We now show that the same is true for a highly charged H-like ion, namely Bi^{82+}.

Our theoretical methods have already been fully described.[3] Our fully relativistic calculations are based on multiconfiguration Dirac-Fock wave functions with Breit and QED corrections obtained from the codes of Grant and co-workers[5–9] with some developments[3] for the continuum part of the problem. Our semirelativistic calculations are based on the solution of the $(2j+1)$-weighted-average single-channel Dirac equation as incorporated[3] in the AUTOSTRUCTURE code.[10–12] Previously,[3] the only two-body interaction that we included was the Coulomb electrostatic. We now look at the effect of the two-body fine-structure interactions,[10] even though the Pauli approximation for the Breit interaction may not be valid[13] and its use with the large-component solution of the Dirac equation is questionable.[13]

The reactions we consider for Bi^{80+} are

$$1s^22s+e^-\rightleftarrows1s^22\bar{p}nl\rightarrow\begin{cases}1s^22snl+h\nu_1\\1s^22\bar{p}n'l'+h\nu_2\end{cases}$$

for $n\geq20$, $n'<20$, and $l'<n'$, and also

$$1s^22s+e^-\rightleftarrows\begin{array}{c}1s^22pnl\\\downarrow\\1s^22\bar{p}+e^-\end{array}\rightarrow\begin{cases}1s^22snl+h\nu_1\\1s^22pn'l'+h\nu_2\end{cases}$$

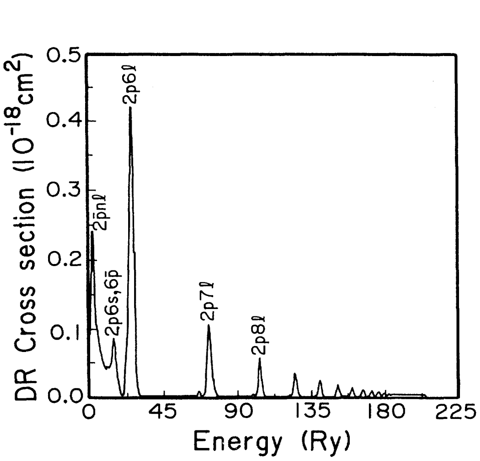

FIG. 1. Semirelativistic DR cross sections for Bi^{80+} convoluted with a 2-Ry FWHM Gaussian.

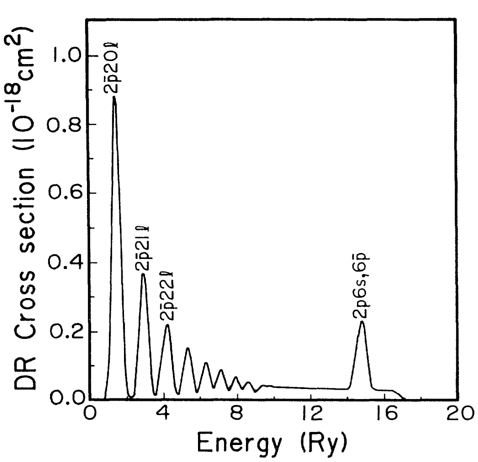

FIG.2. Semirelativistic DR cross sections for Bi^{80+} convoluted with a 0.5-Ry FWHM Gaussian.

for $n \geq 6$, $n' < 6$, and $l' < n'$.

The reaction we consider for Bi^{82+} is

$$1s + e^- \rightleftarrows 2l2l' \rightarrow 1s2l'' + h\nu \ .$$

In Fig. 1 we present our semirelativistic results for the DR of Bi^{80+}. The DR cross sections have been convoluted with a 2-Ry full width at half maximum (FWHM) Gaussian. Previously,[3] we found that our semirelativistic $\Delta n = 0$ results for the DR of U^{89+} were in good agreement with our Dirac-Fock results and that the effect of the Breit interaction was negligible. The results for the $2\bar{p}nl$ series are concentrated in a narrow energy band below the $2p6l$ cross section. An expanded view of this energy region is shown in Fig. 2 for a 0.5-Ry Gaussian; only the $2p6s,6\bar{p}$ resonances of the $2pnl$ series interlope on the $2\bar{p}nl$ series. Since we are using the isolated resonance approximation, no account is taken of any possible interference effects. We note that, as with U^{89+}, we adjusted[3] our semirelativistic $2s$-$2p$ $(j = 1/2, 3/2)$ excitation energies to those calculated in the Dirac-Fock approximation with Breit and QED corrections, so that our resonances should again[3] coincide with those that would have been obtained from a fully relativistic calculation.

In Fig. 3 we present the results of our fully relativistic and semirelativistic calculations for the *KLL* DR resonances of Bi^{82+}. We see the familiar[3,4] three-peak structure $(2s^2, 2s2\bar{p}, 2\bar{p}^{\,2}; 2s2p, 2\bar{p}2p; 2p^2)$ due to the near degeneracy of the $2\bar{p}$ and $2s$ orbital energies. Our semirelativistic results are shown both with and without the effect of two-body fine-structure interactions; they show a preferential enhancement of the lowest-energy peak, but cannot reproduce the full effect of the Breit interaction, which was included in our fully relativistic calculation.

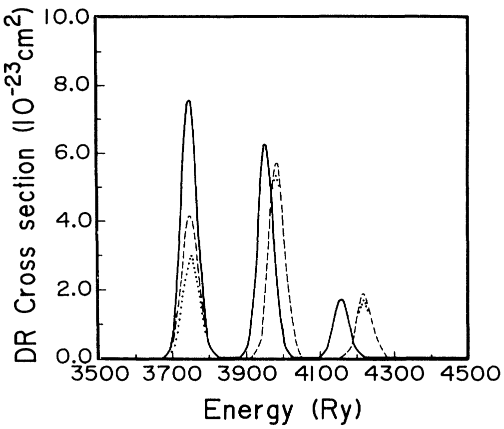

FIG. 3. DR cross section for *KLL* transitions in Bi^{82+} convoluted with a 50-Ry FWHM Gaussian: ——, Dirac-Fock plus Breit; · · · ·, semirelativistic with two-body Coulomb only; — — —, semirelativistic with two-body Coulomb and fine structure.

We look forward to an experimental determination of the cross sections presented here.

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