Li^+ Lamb shift

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In this addendum to a previously published paper [Phys. Rev. A 22, 1563 (1980)] we clarify and correct our discussion of the anomalous-magnetic-moment contribution to the $1s2p\,^3P$ fine structure, following a suggestion by Hata. The result of a reanalysis of our data is a slightly improved value for the J-independent $2P$-$2S$ differential Lamb shift: 1.2542(15) cm^{-1}.

In a recent fast-ion-beam laser spectroscopy experiment,[1] we measured the absolute wave numbers of the $1s2s\,^3S_1$–$1s2p\,^3P_{0,1,2}$ transitions in $^7Li^+$ to a precision of 1.2×10^{-3} cm^{-1}. Our value for the $1s2s\,^3S_1$–$1s2p\,^3P_1$ interval has since been confirmed by a measurement in Heidelberg[2] with a precision of 0.8×10^{-3} cm^{-1}. The aim of these experiments is to test the accuracy of quantum electrodynamic (QED) calculations in the two-electron system. At the time our results appeared, the only available theoretical calculation[3] of the QED contribution in the Li^+ case was not nearly accurate enough to provide a real test. The results of two new calculations will soon be published.[4,5]

The "Lamb shift" in two-electron systems is generally taken to be the difference between the actual energy of a bound state and the energy calculated without QED. Currently the best non-QED energies for Z up to ten come from a variational calculation by Accad, Pekeris, and Schiff (APS).[6] In analyzing our data,[1] we followed the example of previous authors,[7] and indeed of APS as well, in using the term Lamb shift to describe the QED terms not included in the APS calculation. However, as has recently been pointed out to us by Hata,[4] the $\mathcal{O}(\alpha^3)$ QED correction to the $2P$ fine structure (fs) was, in fact, included by APS. The term in question, denoted $E''_{L,2}(nLSJ)$ by Ermolaev,[3] is an anomalous-magnetic-moment correction which can easily be evaluated (to lowest order) once the expectation values of the fine-structure operators have been computed.[8] Since this is the only J-dependent QED correction to $\mathcal{O}(\alpha^3)$, it is not at all surprising that the "Lamb shifts" given in Tables I and II of Ref. 1 are the same for the three fs components, within experimental error.

To carry the analysis a step further, one could subtract off $E''_{L,2}(nLSJ)$ from the APS values and then determine the complete J-dependent Lamb shift for each fs component. This is not particularly instructive, as it impedes comparison of experimental results. Thus we prefer to quote a "J-independent Lamb shift to $\mathcal{O}(\alpha^3)$." The experimental determinations of this quantity listed in Ref. 1 may now be combined to give

$$\mathcal{S}(J \text{ independent}) = 1.2542(15)\ \text{cm}^{-1}\ ,$$

using a simple average of the 11 values in the last column of Table I. In comparing this with the prediction of Ermolaev,[3] we should remove the $E''_{L,2}(nLSJ)$ contribution from his result; however, the numerical value of this term[9] is about -7×10^{-3} cm^{-1}, so that the discussion of the comparison is not significantly altered.

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