

Dynamic Stark shift of the ${}^7\text{Li}(2s \rightarrow 3s)$ transitionLi-Yan Tang,^{1,5,*} M. W. J. Bromley,³ Z.-C. Yan,^{1,2,4} and J. Mitroy⁵¹*State Key Laboratory of Magnetic Resonance and Atomic and Molecular Physics, Wuhan Institute of Physics and Mathematics, Chinese Academy of Sciences, Wuhan 430071, People's Republic of China*²*Center for Cold Atom Physics, Chinese Academy of Sciences, Wuhan 430071, People's Republic of China*³*Centre for Quantum-Atom Optics, School of Mathematics and Physics, The University of Queensland, Brisbane, Queensland 4075, Australia*⁴*Department of Physics, University of New Brunswick, Fredericton, New Brunswick, Canada E3B 5A3*⁵*School of Engineering, Charles Darwin University, Darwin NT 0909, Australia*

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The dynamic dipole polarizabilities for the $3s$ state of the Li atom are computed using Hylleraas and semiempirical approaches. This enables the calculation of the ${}^7\text{Li}(2s \rightarrow 3s)$ Stark shift at photon wavelengths of 610.5 nm and 735.1 nm. They are calculated to be 834.7(5) and $-686.7(25) a_0^3$, respectively. The first two tune-out frequencies for the ${}^7\text{Li}(2s)$ ground state are determined to be 670.971 626(1) nm and 324.192(2) nm, respectively.

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I. INTRODUCTION

High precision transition frequencies for the $\text{Li}(2s \rightarrow 3s)$ transition have been measured for the ${}^6\text{Li}$ and ${}^7\text{Li}$ atoms [1–3]. The experimental procedure involves two-photon excitation from the $2s$ ground state to the $3s$ level, a decay to the $2p$ level, a single-photon excitation to the $3d$ level, and finally photoionization driven by the laser fields used to excite the atom. One contribution to the uncertainty of the final frequency determination is the ac Stark shift of the Li atom $2s$ and $3s$ levels caused by the strong lasers used to excite the Li atom. The ac Stark shifts in those experiments have been determined by varying the laser intensity and measuring the resulting change in the $\text{Li}(2s \rightarrow 3s)$ frequency. Unfortunately, while there have been a number of calculations of the $\text{Li}(2s)$ ground-state static and dynamic polarizabilities [4–12], there have been no first principles calculations of the dynamic polarizabilities of the $\text{Li}(3s)$ level that could be used to assess the reliability of the experimental determination of the Stark shift.

The present paper reports a theoretical determination of the dynamic dipole polarizabilities of the ${}^7\text{Li}(3s)$ state. Earlier calculations of the $\text{Li}(2s)$ dynamic dipole polarizabilities using the Hylleraas approach [4] are then used to help derive estimates of the $\text{Li}(2s \rightarrow 3s)$ Stark shift. In addition, estimates of the tune-out wavelength for the ${}^7\text{Li}(2s)$ state are computed. The tune-out wavelength is the wavelength at which the dynamic dipole polarizability is identically zero [13–15]. Atoms trapped in an optical lattice can be released by changing the wavelength of the trapping laser to that of the tune-out wavelength.

II. THEORETICAL METHOD**A. Dynamic polarizability**

In a weak external electric field, the dynamic 2^ℓ -pole polarizability at photon energy ω for an atom is usually defined

in terms of a sum over all intermediate states including the continuum [18,19],

$$\alpha_\ell(\omega) = \sum_i \frac{f_{gi}^{(\ell)}}{(E_i - E_g)^2 - \omega^2}. \quad (1)$$

The initial state, $\psi_g(\mathbf{r})$, with energy, E_g , is excluded from the summation over i . The 2^ℓ -pole oscillator strength $f_{gi}^{(\ell)}$ from ground state g to excited state i is defined [6,20]

$$f_{gi}^{(\ell)} = \frac{2(E_i - E_g)|\langle \psi_g(\mathbf{r}) \| r^\ell \mathbf{C}^{(\ell)}(\hat{\mathbf{r}}) \| \psi_i(\mathbf{r}) \rangle|^2}{(2\ell + 1)(2L_g + 1)}, \quad (2)$$

where L_g is orbital angular momentum for the ground state. The wave function and energy of the excited state are $\psi_i(\mathbf{r})$ and E_i . The operator, $\mathbf{C}^{(\ell)}(\hat{\mathbf{r}})$ is the ℓ -order spherical tensor.

B. Background

The first stage in the $\text{Li}(2s \rightarrow 3s)$ transition frequency experiment [1,3] involves the two-photon excitation to the $3s$ level. The laser photon with $\lambda = 735.1$ nm, emitted by a Ti:sapphire laser, has an energy of 0.061 98 a.u.. The second stage involves a natural decay to the $2p$ level emitting a photon with an energy of 0.056 05 a.u.. The third stage requires a single-photon excitation from the $2p$ to $3d$ level using a dye laser with a photon wavelength of $\lambda = 610.5$ nm corresponding to an energy of 0.074 63 a.u. [1,3].

The dynamic polarizabilities of the $\text{Li}(2s)$ state are required for photon energies slightly below or slightly above that required to excite the $\text{Li}(2p)$ level. The $\text{Li}(3s)$ state dynamic polarizability needs to be evaluated at an energy between the $6p$ and $7p$ levels for the 735.1 nm photon. The 610.5 nm photon requires the evaluation of the dynamic polarizability at an energy of 0.000 45 a.u. above the ionization threshold.

The present calculation is primarily motivated by the need to generate a better description of the $\text{Li}(2s \rightarrow 3s)$ transition enabling a more reliable estimate of the isotope shift and thus the dimension of the ${}^7\text{Li}$ nuclei [1,2].

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TABLE I. Comparisons of the binding energies (in a.u.) of Li in their low-lying states. The experimental valence binding energies are taken from the National Institute of Standards database [16]. The J -weighted average is used for states with $L \geq 1$. The ground-state energy for ${}^7\text{Li}^+$ is $-7.279\,321\,519\,815\,674\,4$ a.u. [17]. Underlining is used to indicate digits that have not converged with respect to basis set enlargement. The more highly excited states from the Hylleraas calculation do not correspond to physical states.

State	Theory ${}^7\text{Li}$		Experiment
	Hylleraas	CICP	
2^2S	-0.198 130 410 <u>8</u>	-0.198 141	-0.198 142
2^2P	-0.130 236 238 <u>8</u>	-0.130 234	-0.130 235
3^2S	-0.074 177 770 <u>3</u>	-0.074 178	-0.074 182
3^2P	-0.057 234 245 <u>8</u>	-0.057 228	-0.057 236
3^2D	-0.055 605 785 <u>4</u>	-0.055 611	-0.055 606
4^2S	-0.037 <u>524 450 7</u>	-0.038 610	-0.038 615
4^2P	-0.031 <u>388 143 9</u>	-0.031 970	-0.031 975
4^2D	-0.031 273 <u>439 4</u>	-0.031 254	-0.031 274
5^2S	-0.009 129 056 <u>8</u>	-0.023 634	-0.023 637
5^2P	-0.011 244 135 <u>6</u>	-0.020 372	-0.020 374
5^2D	-0.019 861 762 <u>9</u>	-0.020 014	-0.020 012
6^2S	0.032 853 301 <u>11</u>	-0.015 944	-0.015 945
6^2P	0.019 323 626 <u>52</u>	-0.014 105	-0.014 108
6^2D	-0.011 003 726 <u>0</u>	-0.013 898	-0.013 896
7^2S	0.091 767 898 <u>68</u>	-0.011 477	-0.011 479
7^2P	0.064 261 868 <u>31</u>	-0.010 340	-0.010 342

III. RESULTS AND DISCUSSION

A. Dynamic polarizabilities for Li(2s) level

There have been many calculations of the static and dynamic polarizabilities of the ground and excited state of the Li atom [4,6,9,15,21–24]. The present results are based on the Hylleraas and configuration interaction plus core-polarization (CICP) calculations described in Refs. [4,9,23,25]. Two other calculations of note are the single-double all-order many-body perturbation-theory calculations (MBPT-SD) which used an explicitly relativistic Hamiltonian [15,24]. The energies of the CICP and Hylleraas calculations with respect to the ${}^7\text{Li}^+$ core are tabulated in Table I and compared with experiment [16]. It should be noted that the Hylleraas energies are those from a previous calculation designed to give an accurate dynamic polarizability at low photon energies [4]. Considerations of completeness require that a single Hylleraas basis be used for the calculation of the polarizability. A calculation optimized to give the ground-state polarizability is not optimal for the description of highly excited states. It is of course possible for the Hylleraas method to give much more accurate energies for highly excited states provided the basis set parameters are optimized to minimize the energies of those states [26].

The polarizabilities for the ${}^7\text{Li}(2s)$ level are derived from a previous calculation of the dynamic polarizabilities of the two lowest-lying energy states of Li [4]. This calculation and initial calculation of the ${}^7\text{Li}$ polarizabilities were performed using the variational Hylleraas method. Relativistic effects were incorporated by making some adjustments to the energies and matrix elements. Our calculation gave $164.114(30) a_0^3$ for the ground-state polarizability. A later Hylleraas calculation for

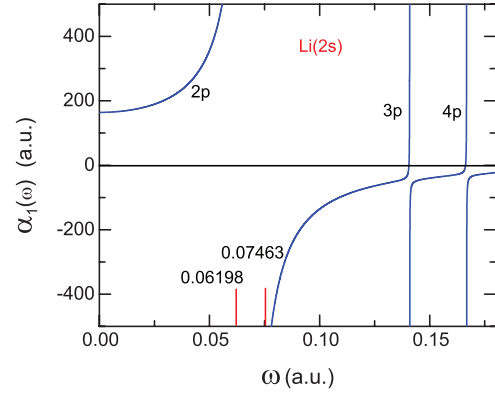


FIG. 1. (Color online) Dynamic dipole polarizability, $\alpha_1(\omega)$, of the ${}^7\text{Li}$ atom in the ground state. The locations of the photon energies used in the Li(2s – 3s) experiment [3] are marked.

${}^7\text{Li}$ which included relativistic corrections by applying perturbation theory to the Breit-Pauli Hamiltonian gave $164.1125(5) a_0^3$ [21,22]. The alternate calculation validates our calculation of the 2s polarizability [4].

The uncertainty in the 2s polarizability is probably an overestimation. It was primarily fixed by a comparison with the $\langle 2s || rC(\mathbf{r}) || 2p \rangle$ matrix element derived from an analysis of the rovibrational spectrum of the Li_2 dimer [27]. The analysis of the Li_2 spectrum was very complex, and it is possible that not all sources of potential systematic error were identified. Nevertheless, the uncertainties adopted in [4] are adopted for the present analysis with the expectation that they will give a conservative estimate of the ${}^7\text{Li}(2s)$ dynamic polarizability.

The dynamic dipole polarizability for the ${}^7\text{Li}(2s)$ state is depicted in Fig. 1. The two critical photon energies for the Li(2s \rightarrow 3s) experiment are indicated in the figure. Table II tabulates the polarizabilities at some selected photon energies. The photon wavelength for the Li(2s \rightarrow 3s) experiment is quite close to the Li(2s \rightarrow 2p) resonant wavelength. Accordingly, the uncertainties in the dynamic dipole polarizability are

TABLE II. Dynamic dipole polarizabilities, $\alpha_1(\omega)$ (in units of a_0^3), for the 2s and 3s states of ${}^7\text{Li}$. The numbers in brackets for the Hylleraas and MBPT-SD polarizabilities are the uncertainties.

ω	Hylleraas	CICP	MBPT-SD
2s			
0.000 00	164.11(3)	164.20	164.16(5) [15]
0.010 00	167.71(3)	167.80	
0.020 00	179.52(3)	179.62	
0.050 00	356.05(6)	356.26	
0.061 98	972.81(18)	973.30	
0.074 63	-777.04(15)	-777.72	
3s			
0.000 00	4131.32(1)	4133.0	4130(1) [15]
0.010 00	6389.67(1)	6391.4	
0.020 00	-10 877.29(1)	-10 890	
0.050 00	-1054.96(8)	-1055.4	
0.061 98	142.8	138.07	
0.074 63	-91.0	-90.72	

largely determined by the uncertainty in the $\langle 2s || r \mathbf{C}(\mathbf{r}) || 2p \rangle$ matrix element. The uncertainties in the excitation energies are very small since these have been set to experimental values. The dynamic polarizability at 0.061 98 a.u. is $972.81(18) a_0^3$. The polarizability is large and positive since the photon energy is just below the $\text{Li}(2s \rightarrow 2p)$ transition energy of 0.067 91 a.u.. The dynamic polarizability at 0.074 63 a.u. of $-777.04(15) a_0^3$ is large and negative since the photon energy is slightly larger than the $\text{Li}(2s \rightarrow 2p)$ transition energy. The CICP calculation gives polarizabilities that are within 0.1% of the Hylleraas calculation. Alternate calculations of the $\alpha_1(\omega)$ polarizabilities [15] have also been listed in Table II.

B. Dynamic polarizabilities for Li(3s) level

The static and dynamic dipole polarizabilities of the ${}^7\text{Li}(3s)$ level at some selected photon energies are given in Table II. The most precise nonrelativistic calculation of the polarizability for finite mass ${}^7\text{Li}$ was $4131.322(5) a_0^3$ [28]. The Hylleraas calculation is not well suited to determining the dynamic polarizabilities at photon energies of 0.061 98 a.u. and 0.074 63 a.u. and no uncertainties are attached to the Hylleraas polarizabilities at these photon energies. As mentioned earlier, it is problematic to construct a single Hylleraas basis capable of describing the entire np Rydberg series as well as the ionization continuum.

The dynamic polarizabilities listed in Table II and plotted in Figs. 2 and 3 were computed with the CICP calculation. The ${}^7\text{Li}(2s \rightarrow 3s)$ Stark shift at 0.061 98 and 0.074 63 a.u. is dominated by the ${}^7\text{Li}(2s)$ polarizability which is close to an order of magnitude larger than the ${}^7\text{Li}(3s)$ polarizability. Therefore, the uncertainty in the ${}^7\text{Li}(3s)$ polarizability is reduced in importance in the ${}^7\text{Li}(2s \rightarrow 3s)$ Stark shift.

The variations in the static ${}^7\text{Li}(3s)$ polarizability between the different CI, Hylleraas, and MBPT-SD calculations are of order $\pm 2 a_0^3$. Assigning an uncertainty of ± 10 a.u. or 0.25% to the $\text{Li}(3s)$ dynamic polarizability is a very conservative choice.

Using a relative uncertainty of 0.25% at 0.061 98 a.u. gives a $\text{Li}(3s)$ dynamic polarizability of $138.1(3) a_0^3$. It can be seen from Fig. 3 that the 0.061 98 a.u. excitation lies midway between the $6p$ and $7p$ excited states. The Stark shift at 0.061 98 a.u. is therefore estimated as $834.7(5) a_0^3$. The

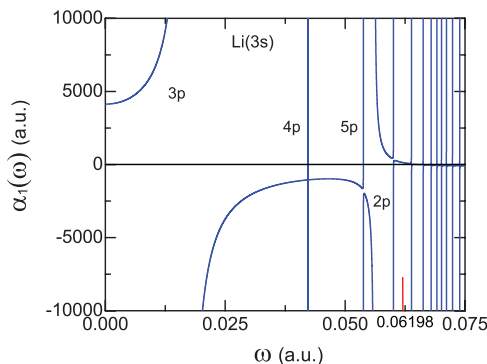


FIG. 2. (Color online) Dynamic dipole polarizability of the $3s$ state of ${}^7\text{Li}$ as a function of photon energy from 0.0 a.u. to 0.075 a.u.. The locations of the $3s \rightarrow np$ transitions have been marked as np .

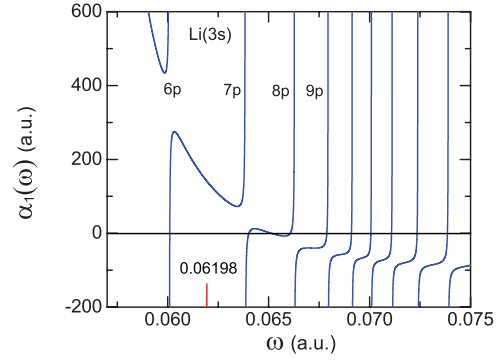


FIG. 3. (Color online) Dynamic dipole polarizability of the $3s$ state of ${}^7\text{Li}$ as a function of photon energy from 0.0575 a.u. to 0.075 a.u.. The positions of the $\text{Li}(3s \rightarrow np)$ excitations have been identified as np .

$\text{Li}(2s \rightarrow 3s)$ energy interval will increase as the electric-field intensity (laser power) increases.

The determination of the $\text{Li}(3s)$ dynamic polarizability at 0.074 63 a.u. is subject to greater uncertainties since the virtual excitation lies in the continuum. The CICP calculation gives $-90.72 a_0^3$. The polarizability is dominated by the $\text{Li}(3s \rightarrow 2p)$ and $\text{Li}(3s \rightarrow 3p)$ transitions and these two terms contribute $-93.18 a_0^3$ to the dynamic polarizability. Although a formal treatment of the continuum contributions to the polarizability at 0.074 63 a.u. is complicated, the continuum contribution is small. We take the value of $-90.72 a_0^3$ as the dynamic polarizability, since the continuum contribution is small and it is known that pseudostate expansions are known to give a good representation of the continuum. A very conservative estimate of the uncertainty would be $93.18 - 90.72 = 2.5 a_0^3$.

Subtracting $-90.72(250)$ from $-777.04(15)$ gives $-686.7(25) a_0^3$ for the ${}^7\text{Li}(2s \rightarrow 3s)$ Stark shift. The ${}^7\text{Li}(2s \rightarrow 3s)$ energy interval will decrease as the laser power at 0.074 63 a.u. photon energy increases.

C. Li(2s) tune-out wavelength

The tune-out wavelength for an atom has been defined as the wavelength for which the dynamic polarizability is equal to zero [13,14]. Atoms trapped in an optical lattice can be released by changing the wavelength of the trapping laser to that of the tune-out wavelength for that atom.

The first tune-out wavelength for the lithium ground state occurs between the $2p_{1/2}$ and $2p_{3/2}$ levels and is largely caused by the cancellation of the contributions from the two levels. The following simplified expression is adopted for the polarizability in the vicinity of the tune-out wavelength:

$$\alpha_1(\omega) = \frac{f_{2p_{1/2}}}{(\Delta E_{2p_{1/2}}^2 - \omega^2)} + \frac{f_{2p_{3/2}}}{(\Delta E_{2p_{3/2}}^2 - \omega^2)} + \alpha_{\text{rem}}(\omega), \quad (3)$$

where $\alpha_{\text{rem}}(\omega)$ is the remainder part of dynamic dipole polarizability. The energy difference, $\Delta E_{2p_{3/2}}$, can be parametrized as $\Delta E_{2p_{3/2}} = \Delta E_{2p_{1/2}}(1 + \delta)$. Parametrizing the reduced matrix

element as

$$\begin{aligned} & |\langle \psi_{2s}(\mathbf{r}) || r \mathbf{C}(\hat{\mathbf{r}}) | \psi_{2p_{3/2}}(\mathbf{r}) \rangle|^2 \\ &= |\langle \psi_{2s}(\mathbf{r}) || r \mathbf{C}(\hat{\mathbf{r}}) | \psi_{2p_{1/2}}(\mathbf{r}) \rangle|^2 (2 + R) \end{aligned} \quad (4)$$

leads to

$$\alpha_1(\omega) = \frac{f_{2p_{1/2}}}{(\Delta E_{2p_{1/2}}^2 - \omega^2)} + \frac{f_{2p_{1/2}}(2 + R)(1 + \delta)}{[(\Delta E_{2p_{1/2}})^2(1 + \delta)^2 - \omega^2]} + \alpha_{\text{rem}}(\omega). \quad (5)$$

The dipole oscillator strength $f_{2p_{1/2}}$ is obtained by multiplying the ${}^7\text{Li}$ relativity corrected reduced matrix element, $\langle \psi_{2s}(\mathbf{r}) || r \mathbf{C}(\hat{\mathbf{r}}) | \psi_{2p}(\mathbf{r}) \rangle$ [4], with the $2s \rightarrow 2p_{1/2}$ energy difference. The background polarizability $\alpha_{\text{rem}}(\omega)$ was computed using the recommended set of matrix elements and energy differences from previous work [4].

The factors R and δ are small. The polarizability for the remainder, $\alpha_{\text{rem}}(\omega)$, changes relatively slowly with ω . A zero-order estimate of the wavelength for small R and δ can be deduced by setting $\alpha_{\text{rem}}(\omega) = 0$. One gets

$$\omega \approx \Delta E_{2p_{1/2}} \left[1 + \frac{\delta^2 + 2\delta}{2R\delta + 4\delta + 2R + 6} \right]. \quad (6)$$

Table III gives a breakdown of the calculations of tune-out wavelengths for the two lowest-energy wavelengths for ${}^7\text{Li}$. Using experimental energies for $2p_{1/2}$ and $2p_{3/2}$ states [29,30] gives $\delta = 0.000\,022\,500\,5$. The value of R was set to $R = 0.000\,024\,107$ from a relativistic model potential calculation [31]. This calculation used a Dirac-Fock wave function to represent the Li^+ core. The valence electrons were expanded as a linear combination of L spinors [32,33] and this basis was used to diagonalize the effective Hamiltonian for the valence electron. A semiempirical polarization potential was included and tuned to reproduce the correct $2p_{1/2}$ and $2p_{3/2}$ energies and the transition matrix elements. The method is very much a relativistic analog of the nonrelativistic calculations used

to compute the CICIP dynamic polarizability [9,25,34]. Using Eq. (6) with these values of R and δ gave a tune-out photon energy of $0.067\,906\,526\,574$ a.u..

The dipole polarizability for the remainder term $\alpha_{\text{rem}}(\omega)$ as estimated at $\omega = 0.067\,906\,526\,574$ a.u. is $2.333\,824\,a_0^3$. Table III shows the tune-out wavelength after initially setting $R = 0$, $\alpha_{\text{rem}}(\omega) = 0.0\,a_0^3$, and then turning these terms on. Setting R and $\alpha_{\text{rem}}(\omega) = 2.333\,824\,2\,a_0^3$ to a finite value changed the tune-out energy in the twelfth significant digit. The lowest tune-out wavelength is largely determined by the photon energies of the two states of the spin-orbit doublet. The agreement with the MBPT-SD calculation [15] is hardly a test of the dynamical correctness of the present and MBPT-SD calculations; rather the agreement is mainly due to choosing the photon energies of the spin-orbit doublet at the experimental values. As a consequence, the approximate result, Eq. (6), gives a very accurate estimate of the tune-out energy. A conservative estimate of the tune-out energy and wavelength would be $0.067\,906\,526\,57(1)$ a.u. and $670.971\,626(1)$ nm, respectively. Uncertainties in the values of R and $\alpha_{\text{rem}}(\omega)$ will have almost no impact, since the inclusion of these terms had also no effect on the tune-out energy.

The second tune-out energy occurs just before the $3s \rightarrow 3p_{1/2}, 3p_{3/2}$ excitations. In this case, the remainder polarizability $\alpha_{\text{rem}}(\omega)$ in Eq. (5) omits the excitations to the $3p_{1/2}$ and $3p_{3/2}$ states. The spin-orbit splitting parameter, $\delta = 0.000\,003\,088\,3$, was set by reference to the experimental energies for $3p_{1/2}$ and $3p_{3/2}$ states [29,30]. The value of R was determined at $R = -0.000\,961\,99$ from the relativistic model potential calculation [31]. The inclusion of $\alpha_{\text{rem}}(\omega)$ resulted in change in the tune-out energy at the fourth significant digit. The inclusion of R resulted in a change in the seventh significant digit.

The uncertainty in the tune-out wavelength was determined by making small perturbations to $\alpha_{\text{rem}}(\omega)$ and $f_{2p_{3/2}}$ and observing the changes (note, the uncertainty in R has a very small effect on the tune-out wavelength). A change in the $\alpha_{\text{rem}}(\omega)$ function of 0.1% resulted in a change in the tune-out

TABLE III. Values of the tune-out wavelength for the ${}^7\text{Li}$ atom. The experimental wavelengths are taken from [29,30]. Wavelengths are given with digits beyond experimental precision to exhibit the sensitivity to changes in the parameters used to characterize the dynamic polarizability.

Resonance	ω (a.u.)	λ_{res} (nm)
$\Delta E_{2p_{1/2}}$	0.067 906 017 273	670.976 658
$\Delta E_{2p_{3/2}}$	0.067 907 545 195	670.961 561
Eq. (6), $R = 0.000\,024\,107$	0.067 906 526 574	670.971 625 650
Eq. (5), $R = 0, \alpha_{\text{rem}}(\omega) = 0$	0.067 906 526 576	670.971 625 631
Eq. (5), $R = 0.000\,024\,107, \alpha_{\text{rem}}(\omega) = 0$	0.067 906 526 572	670.971 625 672
Eq. (5), $R = 0.000\,024\,107, \alpha_{\text{rem}}(\omega) = 2.333\,824$	0.067 906 526 572	670.971 625 672
Recommended	0.067 906 526 6(1)	670.971 626(1)
MBPT-SD [15]	0.067 906 526 6(2)	670.971 625(2)
$\Delta E_{3p_{1/2}}$	0.140 907 184	323.3572
$\Delta E_{3p_{3/2}}$	0.140 907 620	323.3562
Eq. (6) with $R = -0.000\,961\,99$	0.140 907 329	323.356 867
Eq. (5) with $R = 0, \alpha_{\text{rem}}(\omega) = -46.270\,629$	0.140 544 418	324.191 833
Eq. (5) with $R = -0.000\,961\,99, \alpha_{\text{rem}}(\omega) = -46.270\,518$	0.140 544 534	324.191 566
Recommended	0.140 545(1)	324.192(2)
MBPT-SD [15]	0.140 545(9)	324.19(2)

wavelength of 4×10^{-7} nm. Changing $f_{3p_{1/2}}$ by 0.1% resulted in the tune-out wavelength changing by 5×10^{-7} nm.

IV. SUMMARY

The Stark shifts for the ${}^7\text{Li}(2s \rightarrow 3s)$ transition have been computed by a composite method using both Hylleraas and CIRC calculations. The Stark shifts can be used in the interpretation of a recent high-precision measurement of the ${}^7\text{Li}(2s \rightarrow 3s)$ transition energy [1–3]. A composite method was used to calculate the Stark shift. The Hylleraas method was used for the determination of the ${}^7\text{Li}(2s)$ dynamic polarizability, while the CIRC method was used to compute the ${}^7\text{Li}(3s)$ dynamic polarizability. The uncertainty in the Hylleraas calculation is much lower than the uncertainty in the CIRC calculation. However, the overall uncertainty in the Stark shift is less than 1% at the two-photon energies of interest.

Calculations of the two lowest tune-out frequencies for the ground-state ${}^7\text{Li}$ have also been made. The tune-out frequency lying between the $2p_{1/2}$ and $2p_{3/2}$ states is largely determined

by kinematic features like the energy-level positions and dynamical aspects such as $\alpha_{\text{rem}}(\omega)$ have little impact. The recommended value of 670.971 626(1) nm is more precise than the MBPT-SD calculation [15].

The tune-out wavelength adjacent to the $3p$ excitation is more sensitive to the details of the atomic structure description. The recommended value of 324.192(2) nm has a smaller uncertainty than the earlier MBPT-SD calculation [15].

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