Erratum: State-insensitive trapping of Rb atoms: Linearly versus circularly polarized light [Phys. Rev. A 86, 033416 (2012)]

Bindiya Arora and B. K. Sahoo

(Received 11 March 2019; published 1 April 2019)

DOI: 10.1103/PhysRevA.99.049901

In this work, we had investigated magic wavelengths of the $5s\,^2S_{1/2} \rightarrow 5p\,^2P_{1/2;3/2}$ transitions in the rubidium (Rb) atom using linearly and circularly polarized lights. Accurate determination of these magic wavelengths are of immense interest to carry out high-precision measurements in the Rb atom. To find out these magic wavelengths, we had determined dynamic polarizabilities of the ground and $5p\,^2P_{1/2;3/2}$ states very precisely by evaluating electric dipole matrix elements among many low-lying states which were evaluated using the relativistic coupled-cluster method. The static polarizability values of the above states were compared with the previously available results to validate our calculations. The magic wavelengths using linearly polarized light reported were very accurate, whereas they were not correct for the circularly polarized light. This is because we had used a wrong formula, given by Eq. (6) in our paper, to determine dynamic polarizabilities for the circular polarized light. This formula misses a factor of $\frac{1}{2}$ in the vector component contribution and assumes both $\cos(\theta_k)$ and $\cos(\theta_p)$ values to be equal to 1 for the weak magnetic field. In our subsequent works for Cs [1] and Fr [2] atoms, we rectified these errors by expressing the correct formula for the dynamic polarizability of a state with valence orbital v and angular frequency ω of the circularly polarized electric field as

$$\alpha_v(\omega) = \alpha_v^0(\omega) + \mathcal{A}\cos\theta_k \frac{m_j}{2j}\alpha_v^1(\omega) + \left\{\frac{3\cos^2\theta_p - 1}{2}\right\}\frac{3m_j^2 - j(j+1)}{j(2j-1)}\alpha_v^2(\omega), \quad (6)$$

where $\mathcal{A} = 1$ for the right-handed and $\mathcal{A} = -1$ for the left-handed circularly polarized light. Other quantities in the above expression are defined in the original paper. In the absence of a magnetic field (or in a weak magnetic field), $\cos(\theta_k)$ and $\cos(\theta_p)$ are now chosen as 1 and 0, respectively.

Using the rectified formula, we have replotted the dynamic polarizabilities of the ground and $5p\,^2P_{1/2}$ states in Fig. 3, and dynamic polarizabilities of the ground and $5p\,^2P_{3/2}$ states in Fig. 4, which correspond to Figs. 3 and 4 of our paper. The corresponding magic wavelengths and values of the dynamic polarizabilities at these magic wavelengths inferred from the above figures are tabulated in corrected Tables XII and XIII here. Apart from these changes, all other findings and conclusions of our paper remain same.

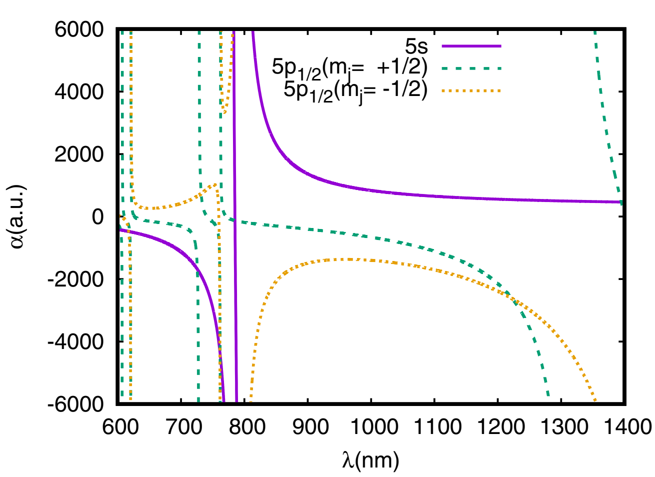

FIG. 3. Magic wavelengths for the $5p_{1/2} - 5s$ transition in Rb using the left-handed circularly polarized light.

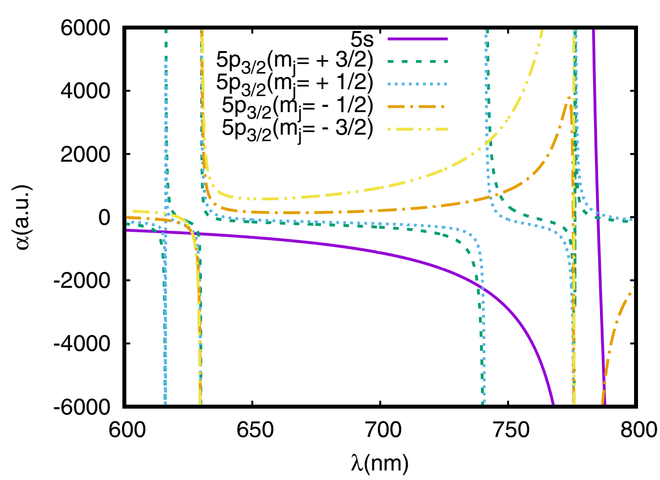

FIG. 4. Magic wavelengths for the $5p_{3/2} - 5s$ transition in Rb using the left-handed circularly polarized light.

TABLE XII. Magic wavelengths λ_{magic} above 600 nm for the $5p_{1/2}-5s$ transition in Rb and the corresponding values of total polarizabilities at the magic wavelengths for the left-circularly polarized laser beam. The wavelengths (in vacuum) are given in nanometers and polarizabilities are given in atomic units. The given m_j values are for the $5p$ states.

Transition: $5p_{1/2}-5s$			
m_j	λ_{magic}	$\alpha(\lambda_{magic})$	λ_{magic} (avg)
1/2	604.57(5)	−427	605
−1/2	617.35(3)	−475	618(2)
1/2	619.02(3)	−482	
1/2	725.73(2)	−1683	726
1/2	761.753(5)	−4397	761.6(4)
−1/2	761.394(4)	−4328	
1/2	785.18(3)	−129	784(2)
−1/2	783.19(2)	6711	
1/2	1394.99(6)	466	1395

TABLE XIII. Magic wavelengths λ_{magic} above 600 nm for the $5p_{3/2}-5s$ transition in Rb and the corresponding values of total polarizabilities at the magic wavelengths for the left-circularly polarized laser beam. The wavelengths (in vacuum) are given in nanometers and polarizabilities are given in atomic units. The given m_j values are for the $5p$ states.

Transition: $5p_{3/2}-5s$			
m_j	λ_{magic}	$\alpha(\lambda_{magic})$	λ_{magic} (avg)
3/2	612.32(9)	−455	613(2)
1/2	614.88(4)	−465	
3/2	628.9(2)	−526	
1/2	627.3(2)	−518	627(3)
−1/2	626.5(1)	−515	
−3/2	626.59(9)	−515	
3/2	630.061(7)	−531	
1/2	630.075(2)	−531	630.07(2)
−1/2	630.087(1)	−531	
3/2	738.09(2)	−2156	739(2)
1/2	740.09(1)	−2255	
3/2	775.92(2)	−13289	
1/2	775.79(1)	−13007	775.8(2)
−1/2	775.78(1)	−12967	
−3/2	775.803(4)	−13029	
3/2	776.130(1)	−13800	
1/2	776.133(1)	−13820	776.13(2)
−1/2	776.146(4)	−13870	
3/2	785.14(3)	−24	
1/2	785.08(4)	120	787(5)
−1/2	787.53(2)	−5397	
−3/2	790.021(1)	−12352	
3/2	1481.0(3)	443	1444(74)
1/2	1407.0(1)	462	

[1] S. Singh, K. Kaur, B. K. Sahoo, and B. Arora, J. Phys. B: At., Mol. Opt. Phys. **49**, 145005 (2016).
[2] S. Singh, B. K. Sahoo, and B. Arora, Phys. Rev. A **94**, 023418 (2016).