

Atomic Physics:
an exploration through problems and solutions
(2nd edition)

We would be greatly indebted to our readers for informing us of errors and misprints in the book by sending an e-mail to: budker@berkeley.edu. The Errata are listed at <http://socrates.berkeley.edu/~budker>. We will do our best to correct problems in subsequent printings of the book.

Here is a list of issues identified so far in the **Second Edition**. They have been, for the most part, corrected in subsequent printings as noted.

Corrections for 2nd printing of Atomic Physics: an exploration through problems and solutions (2nd edition)

General

The binding margin for the entire book appears to be on the wrong side: there is too little white space near the binding and too much white space on the outside edge.

Back cover

The affiliation for author Derek F. Kimball should read:

Derek F. Kimball is an associate professor and chair of the Department of Physics at California State University - East Bay in Hayward, California.

Page 90 — Fig. 2.5:

The dashed vector pointing along z on the left-hand side should be labeled $\vec{B}_0 + \vec{\omega}/\gamma$ instead of just γ .

Page 94 — footnote 7:

The last equation in the footnote is missing brackets and parentheses:

⁷ Equation (2.81) can be derived starting from the usual time-dependent Schrödinger equation:

$$H|\psi\rangle = i\frac{\partial}{\partial t}|\psi\rangle ,$$

then multiplying both sides by U^\dagger and inserting the identity operator UU^\dagger in appropriate locations:

$$\begin{aligned} U^\dagger H U U^\dagger |\psi\rangle &= iU^\dagger \frac{\partial}{\partial t} U U^\dagger |\psi\rangle , \\ H' |\psi'\rangle &= iU^\dagger \frac{\partial}{\partial t} U |\psi'\rangle , \\ H' |\psi'\rangle &= iU^\dagger \left[\left(\frac{\partial U}{\partial t} \right) |\psi'\rangle + U \frac{\partial}{\partial t} |\psi'\rangle \right] . \end{aligned}$$

Here we have made use of Eqs. (2.79) and (2.80), and the above result directly yields Eq. (2.81).

Page 122 — footnote 1:

The matrix in the footnote is missing parentheses:

¹ Introducing relaxation in this way is equivalent to using instead of (3.4) a nonHermitian Hamiltonian

$$\mathbf{H} = \begin{pmatrix} 0 & V(t) \\ V^*(t) & \omega_0 - i\Gamma/2 \end{pmatrix}.$$

We warn the reader that while this works in this case (and some others), in general, it is not correct to “write in” relaxation terms into the Hamiltonian, and in the density matrix formalism [see, for example, Appendix G and Stenholm (1984)] a separate “relaxation matrix” is usually introduced.

Page 128 — Last paragraph of Problem 3.1:

Equation (3.30) is incorrect, which also impacts some of the surrounding discussion. The last paragraph should read:

By solving the coupled differential equations (3.5) and (3.7), one obtains the general analytic formula for the time dependence of the population of the upper state:

$$P(t) = \frac{(2V_0)^2 e^{-\Gamma t/2 - \text{Im}[\sqrt{(2V_0)^2 + (\Delta + i\Gamma/2)^2}]t}}{|(2V_0)^2 + (\Delta + i\Gamma/2)^2|} \left| \frac{1}{2} \left(1 - e^{i[(2V_0)^2 + (\Delta + i\Gamma/2)^2]^{1/2}t} \right) \right|^2. \quad (3.30)$$

Page 202 — Figure 3.29:

Since electron charge is negative, the arrows indicating the direction of the instantaneous dipole moment should actually be reversed in Fig. 3.29.

Our suggested correction, for simplicity, is rather for the caption:

FIG. 3.29 A superposition of the two states shown in Fig. 3.28 (of the form $(|n = 1, L = 0, M = 0\rangle + e^{-i\omega_{PS}t}|n = 2, L = 1, M = 1\rangle)/\sqrt{2}$ in the case shown here) corresponds to an electron displaced to one side of the nucleus. The electron density and the corresponding

electric-dipole moment rotate around the nucleus at a frequency corresponding to the energy interval between the S and P states (one period of such a rotation is shown in the figure), leading to E1 radiation. The arrow indicates the magnitude and points in the direction of the electron density excess (opposite to the instantaneous direction of the electric dipole moment, since the electron charge is negative).

Page 449 — Table B.1:

There are errors in Table B.1 in the columns with the lifetimes and reduced matrix elements. The revised table should read:

Table B.1: Parameters of the lowest-energy resonance transitions from the ground state for hydrogen ($1s \rightarrow 2p_{1/2,3/2}$) and the alkali atoms [the D1(2) transitions: $ns \rightarrow np_{1/2(3/2)}$]. Wavelengths are given in vacuum; $||d_J||$ is the reduced matrix element in the J -basis.

Atom	Upper state	Energy, cm^{-1}	Wavelength, nm	Lifetime, ns	$ d_J , ea_0$
H	$2\ ^2P_{1/2}$	82258.91	121.5674	1.60	1.05
	$2\ ^2P_{3/2}$	82259.27	121.5668	1.60	1.49
Li	$2\ ^2P_{1/2}$	14903.66	670.976	27.1	3.33
	$2\ ^2P_{3/2}$	14904.00	670.961	27.1	4.71
Na	$3\ ^2P_{1/2}$	16956.18	589.755	16.3	3.52
	$3\ ^2P_{3/2}$	16973.38	589.158	16.2	4.98
K	$4\ ^2P_{1/2}$	12985.17	770.109	26.2	4.10
	$4\ ^2P_{3/2}$	13042.89	766.701	26.1	5.80
Rb	$5\ ^2P_{1/2}$	12578.96	794.978	27.7	4.23
	$5\ ^2P_{3/2}$	12816.56	780.241	26.2	5.98
Cs	$6\ ^2P_{1/2}$	11178.24	894.595	34.8	4.49
	$6\ ^2P_{3/2}$	11732.35	852.344	30.4	6.32
Fr	$7\ ^2P_{1/2}$	12236.66	817.216	29.5	4.28
	$7\ ^2P_{3/2}$	13923.20	718.226	21.0	5.90

Page 455 — Equation (D.2):

Equation (D.2) should read:

$$S_i = P_i/P_0, \quad i = 1, 2, 3. \quad (\text{D.2})$$

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Page 90 — Fig. 2.5:

The dashed vector pointing along z on the left-hand side should be labeled $\vec{B}_0 + \vec{\omega}/\gamma$ instead of just $/\gamma$.

Page 396

In the discussion below Eq. (8.85) the condition $v \ll v_m$ should be changed to read $v \gg v_m$.

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The affiliations for author Dmitry Budker should read:

Dmitry Budker is Professor of Physics at Johannes Gutenberg University at Mainz, Germany, Section Leader at the Helmholtz Institute, Mainz, and Professor of the Graduate School at the University of California at Berkeley.

The affiliation for author Derek F. Kimball should read:

Derek F. Kimball is Professor of Physics at California State University – East Bay in Hayward, California.

Acknowledgements

Yasuhiro Shimizu should be thanked.

Page 2 — Problem 1.1

In the second paragraph, the variable Z should be defined as the atomic number.

Page 78 — Problem 2.2

The statement of the problem should read:

Discuss the general scaling of electric polarizabilities with the principal quantum number n for highly excited states, assuming the absence of level degeneracy so that the Stark effect is quadratic rather than linear.

Pages 187 and 190 — Problem 3.17

Part (b) of the problem should be deleted as it is ill-posed.

Pages 254-255 — Problem 4.8

At the end of the statement of the problem 4.8(a) in the middle of page 254, “(In this part of the problem, ignore the electron spin.)” should be deleted.

In the paragraph before Eq. (4.119) the statement “... states with $m = m'$, i.e., $|2, 0, 0\rangle$ and $|2, 1, 0\rangle$ (here we label the states $|n, l, m\rangle$).” should be changed to read:

“... states with $M_J = M'_J$, i.e., $|2, 0, 1/2, 1/2\rangle$ and $|2, 1, 1/2, 1/2\rangle$ (here we label the $2^2S_{1/2}$ and $2^2P_{1/2}$ states using the notation $|n, l, J, M_J\rangle$).”

Equation (4.126) should be modified to read:

$$d_{sp} = -e\langle 2, 1, 1/2, 1/2 | z | 2, 0, 1/2, 1/2 \rangle \quad (4.126)$$