Auger and radiative deexcitation of the 1s2ℓ3ℓ' configurations of lithium-like neon

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X-ray energies, Auger, and radiative decay rates and fluorescence yields have been computed in intermediate coupling for the various states of the 1s2s3s, 1s2s3p, 1s2p3p, 1s2p3s, and 1s2p3d configurations of $_{10}Ne^{7+}$, to supplement recent experimental work on these transitions.

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I. INTRODUCTION

The three-electron configurations $1s2\ell3\ell'$ ($\ell = 0, 1$; $\ell' = 0, 1, 2$) of Ne have been observed in ion-atom collision[1,2] and beam-foil excitation[3] experiments. Knowledge of the Auger and fluorescence yields of these systems is needed to interpret the experimental results. In this paper, we report on a calculation of the pertinent multiplet Auger and x-ray transition rates obtained in intermediate coupling.[4,5] The partial fluorescence yields were calculated for each state αJ that arises in a configuration n:

$$\omega_i(\alpha J,n) = \frac{\Gamma_i^R(\alpha J,n)}{\sum_i \Gamma_i^R(\alpha j,n) + \Gamma^A(\alpha J,n)} . \tag{1}$$

Here, Γ_i^R is the ith partial radiative width and Γ^A is the radiationless width of the decaying state. These partial fluorescence yields are useful to investigate the cascade feeding of other Li-like Ne configurations.[6]

II. AUGER TRANSITION RATES

$$1s2\ell(S_1L_1)3\ell' \ {}^2L_J \rightarrow 1s^2({}^1S)\epsilon\ell_c \ {}^2L_J$$

The Auger transition rates for the pertinent multiplet states were derived in LS coupling. The Auger decay rate, in atomic units, is

$$A[(S_1L_1) \ {}^2L_J] = |M(S_1L_1SL)|^2, \tag{2}$$

where the Auger matrix element $M(S_1L_1SL)$ is

$$M(S_1L_1SL) = (-1)^{L+1}[(2\ell+1)(2\ell'+1)(2S_1+1)/2]^{1/2}\begin{pmatrix}\ell & \ell' & \ell_c\\ 0 & 0 & 0\end{pmatrix}$$

$$\times \delta_{L\ell_c}\sum_{S_2=0,1}(2S_2+1)\begin{Bmatrix}1/2 & 1/2 & S_1\\ 1/2 & 1/2 & S_2\end{Bmatrix}\left[(2\ell'+1)^{-1}\mathcal{R}_\ell(1s\varepsilon\ell_c 3\ell'2\ell)\right.$$

$$\left. + (-1)^{S_2}(2\ell+1)^{-1}R_\ell(1s\varepsilon\ell_c 2\ell 3\ell')\right]. \qquad (3)$$

We have

$$\mathcal{R}_k(1s\varepsilon\ell_c 2\ell 3\ell') = \int_0^\infty\int_0^\infty R_{1s}(r_1)R_{\varepsilon\ell_c}(r_2)\frac{r_<^k}{r_>^{k+1}}R_{2\ell}(r_1)R_{3\ell'}(r_2)dr_1dr_2, \qquad (4)$$

where ε and ℓ_c are the energy and angular momentum of the continuum electron.

In the intermediate coupling scheme, the Auger rates are given by

$$A(\alpha J) = \left|\sum_{S_1L_1}\sum_{LS} C(S_1L_1SLJ)M(S_1L_1SL)\right|^2, \qquad (5)$$

where the $C(S_1L_1SLJ)$ are the mixing coefficients of the wave function for the state αJ.

III. THE MULTIPLET X-RAY TRANSITION RATES

The x-ray transition rates in LS coupling were calculated in dipole approximation, following the approach of Shore and Menzel.[5,7] The x-ray rate, in atomic units, is given by

$$(2J+1)\mathcal{R}(\alpha SLJ,\alpha'S'L'J') = (4/3)k^3\, S(\alpha SLJ,\alpha'SL'J')\delta_{SS'}, \qquad (6)$$

where we have

$$S^{1/2}(\alpha SLJ,\alpha'SL'J') = \langle\alpha'SL'J'||Q^{(1)}||\alpha SLJ\rangle = \mathcal{A}_{line}\times\mathcal{R}_{mult}\times\mathcal{J}(\ell',\ell), \qquad (7)$$

$$\mathcal{A}_{line} = [(2J+1)(2J'+1)]^{1/2} W(SJ'L1;L'J), \tag{8}$$

and

$$\mathcal{J}(\ell',\ell) = (-1)^{\ell'-\ell_>} \ell_>^{1/2} \int P_{n'\ell'}(r) P_{n\ell}(r) r dr. \tag{9}$$

The wave number is

$$k = (E_i - E_f)/27.21c, \tag{10}$$

where the energies E are in electron volts and c is the velocity of light.

The multiplet factors $\mathcal{R}_{mult}$ are listed in Table I.

IV. ELECTROSTATIC-INTERACTION MATRIX ELEMENTS FOR THREE-ELECTRON CONFIGURATIONS

The electrostatic-interaction matrix elements for three-electron configurations were derived using Racah algebra.[7-9] The general expression is

$$\begin{aligned} V &= \langle \ell\ell'(L_1S_1)\ell''LS \left| \Sigma r_{ij}^{-1} \right| \ell\ell'(L_1'S_1')\ell''LS \rangle \\ &= \sum_{L_2,S_2} F(\ell\ell''L_2S_2)[L_1,S_1,L_2,S_2]^{1/2} W(L_1\ell''\ell'L_2;L\ell) \\ &\times W(S_1\ \tfrac{1}{2}\ \tfrac{1}{2}\ S_2;S\ \tfrac{1}{2})[L_1',L_2,S_1',S_2]^{1/2} W(L_1'\ell''\ell'L_2;L\ell) \\ &\times W(S_1'\ \tfrac{1}{2}\ \tfrac{1}{2}\ S_2;S\ \tfrac{1}{2}) + \sum_{L_3S_3} F(\ell'\ell''L_3S_3)[L_1,S_1,L_3,S_3]^{1/2} \\ &\times W(\ell\ell'L\ell'';L_1L_3) W(\tfrac{1}{2}\ \tfrac{1}{2}\ S\ \tfrac{1}{2};S_1S_3)[L_1',S_1',L_3,S_3]^{1/2} \\ &\times W(\ell\ell'L\ell'';L_1'L_3) W(\tfrac{1}{2}\ \tfrac{1}{2}\ S\ \tfrac{1}{2};S_1'S_3) + F(\ell\ell'L_1S_1)\delta_{L_1L_1'}\delta_{S_1S_1'}, \end{aligned} \tag{11}$$

where

$$F(\ell\ell''L_2S_2) = \sum_k [f_k(\ell\ell'')F^k(n\ell,n''\ell'')+g_k(\ell\ell'')G^k(n\ell,n''\ell'')] \tag{12}$$

$$f_k(\ell\ell'') = (-1)^{L_2}[\ell,\ell'']\begin{pmatrix}\ell'' & k & \ell''\\ 0 & 0 & 0\end{pmatrix}\begin{pmatrix}\ell & k & \ell\\ 0 & 0 & 0\end{pmatrix}\begin{Bmatrix}\ell & \ell & k\\ \ell'' & \ell'' & L_2\end{Bmatrix} \tag{13}$$

$$g_k(\ell\ell'') = (-1)^{S_2}[\ell,\ell'']\begin{pmatrix}\ell & k & \ell''\\ 0 & 0 & 0\end{pmatrix}^2\begin{Bmatrix}\ell & \ell'' & k\\ \ell & \ell'' & L_2\end{Bmatrix}. \tag{14}$$

and

$$[L_1,L_2,L_3,\ldots] \equiv (2L_1+1)(2L_2+1)(2L_3+1)\ldots$$

This notation is also used in Sec. V.

V. THE MATRIX ELEMENTS OF THE SPIN-ORBIT INTERACTION FOR THE $\ell^{n-2}\ell'\ell''$ CONFIGURATIONS

The matrix elements of the spin-orbit interaction for $\ell^{n-2}\ell'\ell''$ configurations were calculated following the procedure of Wybourne,[10] through which the following expression can be derived:

$$(\ell^{n-2}\alpha_1S_1L_1\ell'S_2L_2\ell''SLJM|H_{S-O}|\ell^{n-2}\alpha_1'S_1'L_1'\ell'S_2'L_2'\ell''S'L'JM)$$

$$= (-1)^{S'+L+J}\begin{Bmatrix}S & S' & 1\\ L' & L & J\end{Bmatrix}(A_{n\ell}\zeta_{n\ell}+A_{n'\ell'}\zeta_{n'\ell'}+A_{n''\ell''}\zeta_{n''\ell''}), \tag{15}$$

where

$$A_{n\ell} = (-1)^{\delta_1}[S,S',L,L',S_2,S_2',L_2,L_2']^{1/2}\begin{Bmatrix}S & S' & 1\\ S_2' & S_2 & \frac{1}{2}\end{Bmatrix}\begin{Bmatrix}L & L' & 1\\ L_2' & S_2 & \ell''\end{Bmatrix}$$

$$\times\begin{Bmatrix}S_2 & S_2' & 1\\ S_1' & S_1 & \frac{1}{2}\end{Bmatrix}\begin{Bmatrix}L_2 & L_2' & 1\\ L_1' & L_1 & \ell'\end{Bmatrix}[\ell(\ell+1)(2\ell+1)]^{1/2}(\ell^{n-2}\alpha SL||V^{(11)}||\ell^{n-2}\alpha'S'L'), \tag{16}$$

$$A_{n'\ell'} = (-1)^{\delta_2}\delta_{S_1S_1'}\delta_{L_1L_1'}[S,S',L,L',S_2,S_2',L_2,L_2']^{1/2}$$

$$\times (3\ell'(\ell'+1)(2\ell'+1)/2)^{1/2}$$

$$\times \begin{Bmatrix} S & S' & 1 \\ S_2' & S_2 & \frac{1}{2} \end{Bmatrix} \begin{Bmatrix} L & L' & 1 \\ L_2' & L_2 & \ell'' \end{Bmatrix} \begin{Bmatrix} S_2 & S_2' & 1 \\ \frac{1}{2} & \frac{1}{2} & S_1 \end{Bmatrix} \begin{Bmatrix} L_2 & L_2' & 1 \\ \ell' & \ell' & L_1 \end{Bmatrix}, \tag{17}$$

$$A_{n''\ell''} = (-1)^{\delta_3}\delta_{S_2S_2'}\delta_{L_2L_2'}\delta_{L_1L_1'}\delta_{S_1S_1'}[S,S',L,L']^{1/2}$$

$$\times (3\ell''(\ell''+1)(2\ell''+1)/2)^{1/2} \begin{Bmatrix} S & S' & 1 \\ \frac{1}{2} & \frac{1}{2} & S_2 \end{Bmatrix} \begin{Bmatrix} L & L' & 1 \\ \ell'' & \ell'' & L_2 \end{Bmatrix} \tag{18}$$

and

$$\delta_1 = S_2+L_2+S_2'+L_2'+S_1+L_1+S'+L'+\ell'+\ell''+1, \tag{19}$$

$$\delta_2 = 2S_2+S_1+L_1+S'+L'+\ell'+\ell''+1, \tag{20}$$

$$\delta_3 = S_2+L_2+S+L+\ell''+\frac{1}{2}\ . \tag{21}$$

Furthermore, we have

$$(\ell^{n-2}\alpha SL||V^{(11)}||\ell^{n-2}\alpha'S'L') = (n-2)\sqrt{\frac{3}{2}}[S,L,S',L']^{1/2}$$

$$\times \sum_{\overline{L},\overline{S}} (\ell^{n-2}SL\{|\ell^{n-3}\overline{SL})(\ell^{n-3}\overline{SL}|\}\ell^{n-2}S'L'$$

$$\times \begin{Bmatrix} S & S' & 1 \\ \frac{1}{2} & \frac{1}{2} & \overline{S} \end{Bmatrix} \begin{Bmatrix} L & L' & 1 \\ \ell & \ell & \overline{L} \end{Bmatrix} (-1)^{\overline{S}+\overline{L}+S+L+\ell+\frac{1}{2}}\ . \tag{22}$$

VI. NUMERICAL CALCULATIONS

A. Atomic model

The single-particle wave functions used in the present calculations were generated through the Herman-Skillman[11] Hartree-Slater model with Kohn-Sham[12] exchange potential. The frozen-orbital approximation is used in the calculation of transition probabilities.

B. Auger and x-ray energies

Average Auger and x-ray energies were used for all multiplet transition-rate calculations. The Auger energies were taken from the work of Groeneveld *et al.*[3] The x-ray energies were calculated using Froese's Hartree-Fock program[13]; they are listed in Table II.

C. Calculation of multiplet Auger and x-ray transition rates in intermediate coupling

Auger and x-ray transition rates were computed in LS coupling from expressions derived in Secs. II and III. Then the mixing due to spin-orbit interaction was included. The electrostatic-interaction matrix elements were evaluated from the formula derived in Sec. IV, and the spin-orbit interaction matrix elements were calculated from the expression obtained in Sec. V. The numerical values of the Slater integrals and spin-orbit parameters $\zeta_{n\ell}$ were calculated in the present atomic model. The mixing parameters $C(S_1L_1SLJ)$ in the intermediate coupling scheme were obtained by diagonalizing the energy matrix.

VII. RESULTS AND DISCUSSION

Auger and x-ray transition probabilities, as well as fluorescence yields $\omega_1(LSJ)$, are listed in Tables III-VII for all initial states pertaining to the configurations 1s2s3s, 1s2s3p, 1s2p3p, 1s2p3s, and 1s2p3d. All x-ray transitions with $\Delta n=1$ and $\Delta n=2$ are included. X-ray transitions with $\Delta n=0$ were neglected because their rates are of the order of 10^{-9} a.u., much smaller than the dominant branches in the decay of these states. Also neglected was the contribution due to the magnetic interaction to the Auger decay of the quartet states, estimated to be $\sim 10^{-9}$ a.u.[14]

It is seen from Table II that the x-ray energies fall into three distinct groups. One group comprises the range from 120 to 160 eV; these transitions have not been observed experimentally.[1,2] A second group, with energies from 906 to 920 eV, will mix with x rays either from the KL^6 charge state or from the KL^7 charge state.[1,2] The radiative transitions in the third group, from 1030 to 1050 eV, which originate from the 1s2s3p and 1s2p3p configurations, have been observed.[1,2] The 1s2s3p and 1s2p3p configurations have the capability of feeding $1s2s^2$ and 1s2s2p configurations, respectively; this fact is consistent with the experimental observation that the $1s2s^2$ and 1s2s2p configurations are overpopulated.[6]

Most of the quartet states (cf. Tables III-VII) decay predominantly by L x-ray emission to the quartet states of the 1s2s2p and $1s2p^2$ configurations. As a result, multiplet states in the 1s2s2p and $1s2p^2$ configurations are populated nonstatistically, and furthermore, the x-ray intensity ratio $^4P/^2P$ of the KL^6 charge state is boosted. This increase in the KL^6 $^4P/^2P$ ratio will narrow the gap between the theoretically calculated[5] and observed intensity ratios.

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REFERENCES

1. D. L. Matthews, B. M. Johnson, and C. F. Moore, Phys. Rev. A 10, 451 (1974); D. L. Matthews, B. M. Johnson, L. E. Smith, J. J. Mackey, and C. F. Moore, Phys. Lett. 48A, 93 (1974).
2. R. L. Kauffman, F. Hopkins, C. W. Woods, and P. Richard, Phys. Rev. Lett. 31, 621 (1973).
3. K. O. Groeneveld, R. Mann, G. Nolts, S. Schumann, R. Spohr and B. Fricke, Z. Physik A 274, 191 (1975) and K. O. Groeneveld, private communication.
4. M. H. Chen and B. Crasemann, Phys. Rev. A 10, 2232 (1974).
5. M. H. Chen and B. Crasemann, Phys. Rev. A 12, 959 (1975).
6. D. L. Matthews, R. J. Fortner, D. Schneider and C. F. Moore, Phys. Rev. A 14, 1561 (1976).
7. B. W. Shore and D. H. Menzel, Principles of Atomic Spectra (Wiley, New York, 1968); Astrophys. J. Suppl. Ser. 12, 187 (1965).
8. E. U. Condon and G. H. Shortley, The Theory of Atomic Spectra (Cambridge, U.P., Cambridge, England, 1953).
9. I. I. Sobel'man, Introduction to the Theory of Atomic Spectra (Pergamon Press, New York, 1972).
10. B. G. Wybourne, Spectroscopic Properties of Rare Earths (Wiley, New York, 1965).
11. F. Herman and S. Skillman, Atomic Structure Calculations (Prentice-Hall, Englewood Cliffs, N.J., 1963).
12. W. Kohn and L. J. Sham, Phys. Rev. 140, A1133 (1965).
13. C. Froese-Fischer, Comput. Phys. Commun. 4, 107 (1972).
14. K. T. Cheng, C. P. Lin, and W. R. Johnson, Phys. Lett. 48A, 437 (1974).

TABLE I. Multiplet factors.

Transition	$\mathcal{R}_{mult}$	$\mathcal{J}$
$ss'(S_1L)s''SLJ \to ss'(S_1L)pSL'J'$	1	$\mathcal{J}(p,s)$
$ss'(S_1L_1)pSLJ \to s^2s'SL'J'$	$[(2S_1+1)/2]^{1/2}$	$\mathcal{J}(s,p)$
$ss'(S_1L_1)pSLJ \to ss'^2SL'J'$	$(-1)^{1-S_1}[(2S_1+1)/2]^{1/2}$	$\mathcal{J}(s,p)$
$sp(S_1L_1)p'SLJ \to s^2pSL'J'$	$(-1)^{L}[(2S_1+1)(2L+1)/6]^{1/2}$	$\mathcal{J}(s,p)$
$sp(S_1L_1)p'SLJ \to s^2p'SL'J'$	$[2(2L+1)/3]^{1/2}\delta_{S,0}$	$\mathcal{J}(s,p)$
$sp(S_1L_1)p'SLJ \to sp(S_1L_1)s'SL'J'$	$(-1)^{L}[(2L+1)/3]^{1/2}$	$\mathcal{J}(s,p)$
$sp(S_1L_1)s'SLJ \to s^2s'SL'J'$	$2^{1/2}\delta_{S,0}$	$\mathcal{J}(s,p)$
$sp(S_1L_1)s'SLJ \to sp^2(S_1'L_1')SL'J'$	$(-1)^{S-1/2}(2/3)^{1/2}[S_1,S_1',S_1']^{1/2}$	$\mathcal{J}(p,s)$
	$\times \begin{Bmatrix} 1/2 & 1/2 & S_1 \\ S & 1/2 & S_1' \end{Bmatrix}$	$\mathcal{J}(p,s)$
$sp(S_1L_1)dSLJ \to s^2dSL'J'$	$[2(2L+1)/3]^{1/2}\delta_{S,0}$	$\mathcal{J}(s,p)$
$sp(S_1L_1)dSLJ \to sp^2(S_1'L_1')SL'J'$	$(-1)^{L+S+1/2}\sqrt{2}[S_1,S_1',L_1',L]^{1/2}$	
	$\times \begin{Bmatrix} 1/2 & 1/2 & S_1 \\ S & 1/2 & S_1' \end{Bmatrix} \begin{Bmatrix} 1 & 1 & L_1' \\ 1 & L & 2 \end{Bmatrix}$	$\mathcal{J}(p,d)$

TABLE II. Theoretical x-ray energies.

Initial configuration	Initial state	Final configuration	Final state	Energy (eV)
1s2s3s	^4S	1s2s2p	^4P	139
1s2s3p	$(^1S)^2P$	$1s^2 2s$	^2S	1048
	$(^3S)^2P$		^2S	1039
	$(^3S)^4P$		^2S	1037
1s2s3p	$(^1S)^2P$	$1s2s^2$	^2S	153
	$(^3S)^2P$		^2S	144
	$(^3S)^4P$		^2S	142
1s2p3s	$(^1P)^2P$	$1s^2 3s$	^2S	918
	$(^3P)^2P$		^2S	912
	$(^3P)^4P$		^2S	909
1s2p3s	$(^1P)^2P$	$1s2p^2$	^2S	127
	$(^1P)^2P$		^2P	132
	$(^1P)^2P$		^2D	134
	$(^3P)^2P$		^2S	121
	$(^3P)^2P$		^2P	126
	$(^3P)^2P$		^2D	128
	$(^3P)^4P$		^4P	134
1s2p3p	$(^1P)^2S$	$1s^2 2p$	^2P	1043
	$(^3P)^2S$			1038
	$(^1P)^2P$			1041
	$(^3P)^2P$			1032

TABLE II continued

Initial configuration	Initial state	Final configuration	Final state	Energy (eV)
	$(^1P)^2D$			1041
	$(^3P)^2D$			1036
	$(^3P)^4S$			1032
	$(^3P)^4P$			1034
	$(^3P)^4D$			1031
1s2p3p	$(^1P)^2S$	$1s^23p$	^2P	918
	$(^3P)^2S$			913
	$(^1P)^2P$			916
	$(^3P)^2P$			907
	$(^1P)^2D$			916
	$(^3P)^2D$			911
	$(^3P)^4S$			907
	$(^3P)^4P$			909
	$(^3P)^4D$			906
1s2p3p	$(^1P)^2S$	1s2p2s	$(^1P)^2P$	154
	$(^3P)^2S$		$(^3P)^2P$	141
	$(^1P)^2P$		$(^1P)^2P$	152
	$(^3P)^2P$		$(^3P)^2P$	135
	$(^1P)^2D$		$(^1P)^2P$	151
	$(^3P)^2D$		$(^3P)^2P$	139
	$(^3P)^4S$		$(^3P)^4P$	155
	$(^3P)^4P$		$(^3P)^4P$	157
	$(^3P)^4D$		$(^3P)^4P$	154

TABLE II continued

Initial configuration	Initial state	Final configuration	Final state	Energy (eV)
1s2p3d	$(^1P)^2P$	$1s^2 3d$	^2D	920
	$(^3P)^2P$			914
	$(^1P)^2D$			918
	$(^3P)^2D$			910
	$(^1P)^2F$			919
	$(^3P)^2F$			913
	$(^3P)^4P$			912
	$(^3P)^4D$			911
	$(^3P)^4F$			909
1s2p3d	$(^1P)^2P$	$1s2p^2$	^2S	135
			^2P	141
			^2D	143
	$(^3P)^2P$		^2S	129
			^2P	135
			^2D	136
	$(^1P)^2D$		^2S	134
			^2P	139
			^2D	141
	$(^3P)^2D$		^2S	125
			^2P	130
			^2D	132

TABLE II continued

Initial configuration	Initial state	Final configuration	Final state	Energy (eV)
	$(^1P)^2F$		^2S	134
			^2P	140
			^2D	142
	$(^3P)^2F$		^2S	128
			^2P	133
			^2D	135
	$(^3P)^4P$		^4P	143
	$(^3P)^4D$		^4P	142
	$(^3P)^4F$		^4P	140

TABLE III. Auger and x-ray decay rates (in atomic units[a]) and fluorescence yields for states of the $1s2s(S_1L_1)3sSLJ$ configuration of $_{10}Ne^{7+}$.

Initial state[b]	Auger rate	X-ray rate ($L_{2,3}$)	Total decay rate	Fluorescence yield $\omega_{L_{2,3}}$
$(^1S)^2S_{1/2}$	2.326(-4)	-	2.326(-4)	-
$(^3S)^2S_{1/2}$	6.158(-4)	-	6.158(-4)	-
$(^3S)^4S_{3/2}$	0	1.037(-6)	1.037(-6)	1.00

[a]One atomic unit equals 4.134×10^{16} sec^{-1} = 27.21 eV/$\hbar$.

[b]State listed is the dominant component in the wavefunction expansion.

TABLE IV. Auger and x-ray decay rates (in atomic units) and fluorescence yields for states of the $1s2s(S_1L_1)3pSLJ$ configuration of $_{10}Ne^{7+}$.

Initial state	Auger rate	X-ray rates K	X-ray rates L_1	Total decay rate	Fluorescence yields ω_K	Fluorescence yields ω_{L_1}
$(^1S)^2P_{1/2}$	4.021(-4)	1.304(-5)	1.055(-6)	41.62(-5)	3.13(-2)	2.53(-3)
$(^3S)^2P_{1/2}$	1.723(-4)	3.427(-5)	3.624(-6)	21.02(-5)	0.163	1.72(-2)
$(^3S)^4P_{1/2}$	8.941(-8)	1.828(-8)	1.904(-9)	1.096(-7)	0.167	1.73(-2)
$(^1S)^2P_{3/2}$	4.025(-4)	1.301(-5)	1.058(-6)	41.66(-5)	3.12(-2)	2.54(-3)
$(^3S)^2P_{3/2}$	1.721(-4)	3.427(-5)	3.618(-6)	21.00(-5)	0.163	1.72(-2)
$(^3S)^4P_{3/2}$	2.462(-7)	5.038(-8)	5.244(-9)	3.018(-7)	0.167	1.74(-2)

TABLE V. Auger and x-ray decay rates (in atomic units) and fluorescence yields for states of the $1s2p(S_1L_1)3pSLJ$ configuration of $_{10}Ne^{7+}$.

Initial state	Auger rate	X-ray rates K	X-ray rates L_1	Total decay rate	Fluorescence yields ω_K	Fluorescence yields ω_{L_1}
$(^1P)^2S_{1/2}$	5.088(-4)	1.566(-4)	2.618(-6)	66.80(-5)	0.234	0.004
$(^3P)^2S_{1/2}$	1.347(-4)	8.519(-5)	2.618(-6)	22.25(-5)	0.383	0.012
$(^1P)^2P_{1/2}$	2.318(-6)	2.045(-4)	2.618(-6)	20.94(-5)	0.977	0.013
$(^3P)^2P_{1/2}$	7.889(-7)	3.671(-5)	2.618(-6)	4.013(-5)	0.915	0.065
$(^3P)^4P_{1/2}$	3.840(-7)	8.144(-7)	2.618(-6)	0.381(-5)	0.214	0.688
$(^3P)^4D_{1/2}$	7.390(-9)	3.970(-7)	2.618(-6)	0.302(-5)	0.131	0.868
$(^1P)^2P_{3/2}$	1.714(-6)	2.056(-4)	2.618(-6)	20.99(-5)	0.980	0.012
$(^3P)_2P_{3/2}$	2.843(-6)	2.892(-5)	2.618(-6)	3.438(-5)	0.841	0.076
$(^1P)^2D_{3/2}$	8.169(-4)	1.869(-4)	2.618(-6)	100.64(-5)	0.186	0.003
$(^3P)^2D_{3/2}$	6.371(-4)	5.489(-5)	2.618(-6)	69.46(-5)	0.079	0.004
$(^3P)^4S_{3/2}$	7.084(-7)	7.380(-6)	2.618(-6)	1.071(-5)	0.689	0.245
$(^3P)^4P_{3/2}$	5.530(-7)	1.605(-7)	2.618(-6)	0.333(-5)	0.048	0.787
$(^3P)^4D_{3/2}$	9.554(-9)	3.046(-7)	2.618(-6)	0.292(-5)	0.103	0.897
$(^1P)^2D_{5/2}$	9.102(-4)	1.791(-4)	2.618(-6)	109.19(-5)	0.164	0.002
$(^3P)^2D_{5/2}$	5.459(-4)	6.195(-5)	2.618(-6)	61.05(-5)	0.101	0.004
$(^3P)^4P_{5/2}$	3.655(-6)	8.709(-7)	2.618(-6)	0.715(-5)	0.122	0.366
$(3P)^4D_{5/2}$	1.603(-9)	2.334(-7)	2.618(-6)	0.285(-5)	0.081	0.919
$(^3P)^4D_{7/2}$	0	0	2.618(-6)	0.262(-5)	0	1.00

TABLE VI. Auger and x-ray decay rates (in atomic units) and fluorescence yields for states of the $1s2p(S_1L_1)3sSLJ$ configuration of $_{10}Ne^{7+}$.

Initial state	Auger rate	X-ray rates K	X-ray rates $L_{2,3}$	Total decay rate	Fluorescence yields ω_K	Fluorescence yields $\omega_{L_{2,3}}$
$(^1P)^2P_{1/2}$	1.991(-6)	1.937(-4)	7.639(-7)	19.65(-5)	0.986	0.004
$(^3P)^2P_{1/2}$	3.915(-4)	2.726(-6)	1.218(-6)	39.55(-5)	0.007	0.003
$(^3P)^4P_{1/2}$	2.714(-7)	6.562(-8)	6.609(-7)	9.979(-7)	0.066	0.662
$(^1P)^2P_{3/2}$	6.734(-6)	1.956(-4)	7.943(-7)	20.31(-5)	0.963	0.004
$(^3P)^2P_{3/2}$	3.864(-4)	6.818(-7)	1.188(-6)	38.83(-5)	0.002	0.003
$(^3P)^4P_{3/2}$	6.514(-7)	1.978(-7)	6.612(-7)	1.510(-6)	0.131	0.438
$(^3P)^4P_{5/2}$	0	0	6.607(-7)	6.607(-7)	0	1.00

TABLE VII. Auger and x-ray decay rates (in atomic units) and fluorescence yields for states of the $1s2p(S_1L_1)3dSLJ$ configuration of $_{10}Ne^{7+}$.

Initial state	Auger rate	X-ray rates K	X-ray rates $L_{2,3}$	Total decay rate	Fluorescence yields ω_K	Fluorescence yields $\omega_{L_{2,3}}$
$(^1P)^2P_{1/2}$	8.668(-6)	1.840(-4)	7.061(-6)	19.97(-5)	0.921	3.54(-2)
$(^3P)^2P_{1/2}$	2.932(-7)	1.066(-5)	7.193(-6)	1.814(-5)	0.588	0.396
$(^3P)^4P_{1/2}$	6.733(-10)	1.805(-8)	6.048(-6)	6.066(-6)	2.98×10^{-3}	0.997
$(^3P)^4D_{1/2}$	1.507(-8)	3.999(-7)	1.052(-5)	1.094(-5)	3.66(-2)	0.962
$(^1P)^2P_{3/2}$	8.769(-6)	1.868(-4)	6.975(-6)	20.26(-5)	0.922	3.44(-2)
$(^3P)^2P_{3/2}$	1.946(-7)	8.006(-6)	7.263(-6)	1.546(-5)	0.518	0.470
$(^1P)^2D_{3/2}$	3.429(-10)	1.918(-4)	9.558(-6)	20.14(-5)	0.952	4.75(-2)
$(^3P)^2D_{3/2}$	2.062(-9)	2.947(-6)	4.522(-6)	7.471(-6)	0.394	0.605
$(^3P)^4P_{3/2}$	1.458(-9)	7.113(-8)	6.409(-6)	6.481(-6)	1.10(-2)	0.989
$(^3P)^4D_{3/2}$	9.073(-9)	3.078(-7)	1.014(-5)	1.045(-5)	2.95(-2)	0.970
$(^3P)^4F_{3/2}$	2.107(-11)	3.226(-9)	1.730(-7)	1.762(-7)	1.83(-2)	0.982
$(^1P)^2F_{5/2}$	2.114(-4)	1.650(-4)	9.085(-6)	38.55(-5)	0.428	2.36(-2)
$(^3P)^2F_{5/2}$	1.117(-8)	2.964(-5)	5.163(-6)	3.481(-5)	0.851	0.148
$(^1P)^2D_{5/2}$	2.997(-7)	1.923(-4)	9.498(-6)	20.18(-5)	0.953	4.71(-2)
$(^3P)^2D_{5/2}$	1.055(-7)	2.289(-6)	4.689(-6)	7.084(-6)	0.323	0.662
$(^3P)^4P_{5/2}$	4.401(-10)	2.501(-7)	6.955(-6)	7.205(-6)	3.47(-2)	0.965
$(^3P)^4D_{5/2}$	8.630(-9)	2.753(-7)	9.534(-6)	9.818(-6)	2.80(-2)	0.971
$(^3P)^4F_{5/2}$	5.440(-8)	2.072(-7)	1.230(-7)	3.846(-7)	0.539	0.320
$(^1P)^2F_{7/2}$	2.115(-4)	1.585(-4)	9.686(-6)	37.97(-5)	0.417	2.55(-2)
$(^3P)^2F_{7/2}$	2.537(-7)	3.523(-5)	4.683(-6)	4.016(-5)	0.877	0.117
$(^3P)^4D_{7/2}$	6.543(-8)	9.557(-7)	1.044(-5)	1.147(-5)	8.33(-2)	0.910
$(^3P)^4F_{7/2}$	7.003(-8)	3.266(-7)	8.201(-8)	4.786(-7)	0.682	0.171