

1 H																	2 He									
3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne									
11 Na	12 Mg											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar									
19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr									
37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe									
55 Cs	56 Ba											72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn
87 Fr	88 Ra											104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds	111 Rg	112 Cn	113 Nh	114 Fl	115 Mc	116 Lv	117 Ts	118 Og

57 La	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu
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89 Ac	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr
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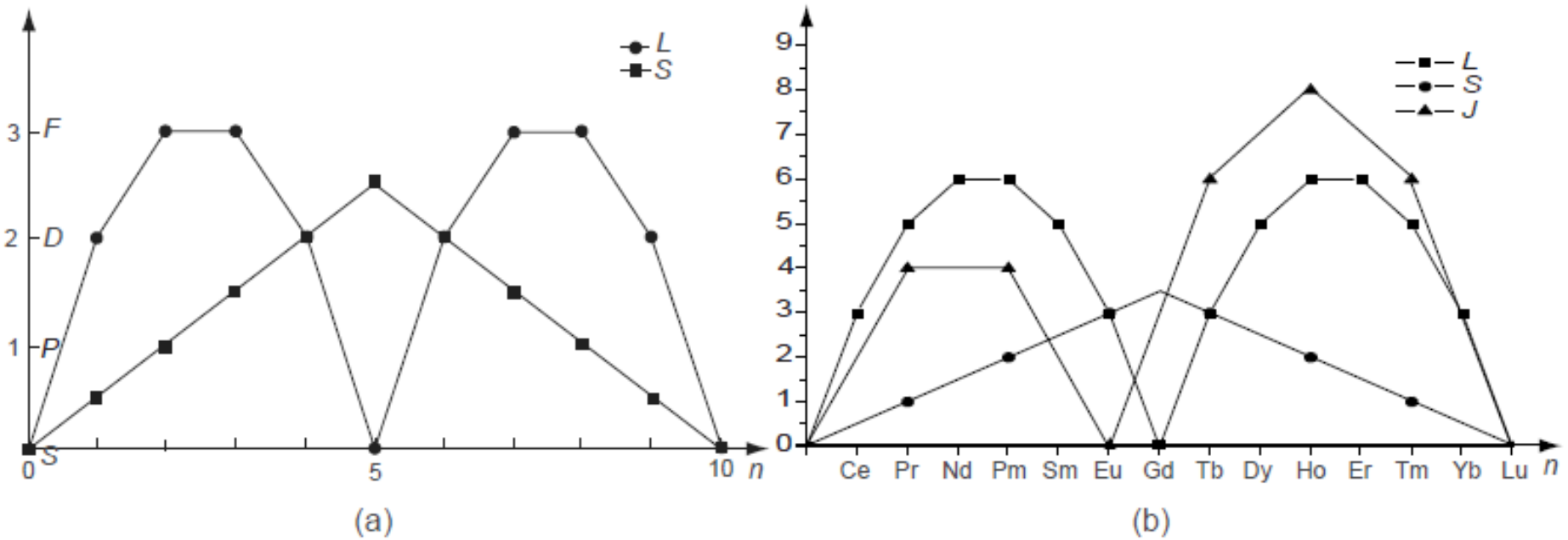


Figure 4.4

(a) L and S for the series of $3d^n$ ions; (b) L , S and J for the series of trivalent $4f$ ions.

interesting phenomena in magnetism, including magnetocrystalline anisotropy, magnetostriction, anisotropic magnetoresistance and the anomalous planar and spin Hall effect.

Table 4.5. Spin-orbit coupling constants for ions in the $3d$ and $4f$ series, in kelvin. $\Delta\varepsilon$ is the energy of the first excited multiplet

	Ion	λ	Λ	$\Delta\varepsilon$
$3d^1$	Sc^{2+}	124	124	310
$3d^2$	Ti^{2+}	176	88	264
$3d^3$	V^{2+}	246	82	205
$3d^4$	Cr^{2+}	340	85	85
$3d^6$	Fe^{2+}	656	-164	656
$3d^7$	Co^{2+}	818	-272	1224
$3d^8$	Ni^{2+}	987	-494	3948
$4f^1$	Ce^{3+}	920	920	3220
$4f^2$	Pr^{3+}	1080	540	2700
$4f^3$	Nd^{3+}	1290	430	2365
$4f^4$	Pm^{3+}	1540	380	1900
$4f^5$	Sm^{3+}	1730	350	1225
$4f^6$	Eu^{3+}	1950	330	330
$4f^8$	Tb^{3+}	2450	-410	2460
$4f^9$	Dy^{3+}	2730	-550	4125
$4f^{10}$	Ho^{3+}	3110	-780	6240
$4f^{11}$	Er^{3+}	3510	-1170	8775
$4f^{12}$	Tm^{3+}	3800	-1900	11400
$4f^{13}$	Yb^{3+}	4140	-4140	14490

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ion	shell	S	L	J	term	p	p_{exp}
Ce ³⁺	4f ¹	$\frac{1}{2}$	3	$\frac{5}{2}$	² F _{5/2}	2.54	2.51
Pr ³⁺	4f ²	1	5	4	³ H ₄	3.58	3.56
Nd ³⁺	4f ³	$\frac{3}{2}$	6	$\frac{9}{2}$	⁴ I _{9/2}	3.62	3.3–3.7
Pm ³⁺	4f ⁴	2	6	4	⁵ I ₄	2.68	–
Sm ³⁺	4f ⁵	$\frac{5}{2}$	5	$\frac{5}{2}$	⁶ I _{5/2}	0.85	1.74
Eu ³⁺	4f ⁶	3	3	0	⁷ F ₀	0.0	3.4
Gd ³⁺	4f ⁷	$\frac{7}{2}$	0	$\frac{7}{2}$	⁸ S _{7/2}	7.94	7.98
Tb ³⁺	4f ⁸	3	3	6	⁷ F ₆	9.72	9.77
Dy ³⁺	4f ⁹	$\frac{5}{2}$	5	$\frac{15}{2}$	⁶ H _{15/2}	10.63	10.63
Ho ³⁺	4f ¹⁰	2	6	8	⁵ I ₈	10.60	10.4
Er ³⁺	4f ¹¹	$\frac{3}{2}$	6	$\frac{15}{2}$	⁴ I _{15/2}	9.59	9.5
Tm ³⁺	4f ¹²	1	5	6	³ H ₆	7.57	7.61
Yb ³⁺	4f ¹³	$\frac{1}{2}$	3	$\frac{7}{2}$	² F _{7/2}	4.53	4.5
Lu ³⁺	4f ¹⁴	0	0	0	¹ S ₀	0	0

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ion	shell	S	L	J	term	p_1	p_{exp}	p_2
Ti ³⁺ , V ⁴⁺	3d ¹	$\frac{1}{2}$	2	$\frac{3}{2}$	${}^2D_{3/2}$	1.55	1.70	1.73
V ³⁺	3d ²	1	3	2	3F_2	1.63	2.61	2.83
Cr ³⁺ , V ²⁺	3d ³	$\frac{3}{2}$	3	$\frac{3}{2}$	${}^4F_{3/2}$	0.77	3.85	3.87
Mn ³⁺ , Cr ²⁺	3d ⁴	2	2	0	5D_0	0	4.82	4.90
Fe ³⁺ , Mn ²⁺	3d ⁵	$\frac{5}{2}$	0	$\frac{5}{2}$	${}^6S_{5/2}$	5.92	5.82	5.92
Fe ²⁺	3d ⁶	2	2	4	5D_4	6.70	5.36	4.90
Co ²⁺	3d ⁷	$\frac{3}{2}$	3	$\frac{9}{2}$	${}^4F_{9/2}$	6.63	4.90	3.87
Ni ²⁺	3d ⁸	1	3	4	3F_4	5.59	3.12	2.83
Cu ²⁺	3d ⁹	$\frac{1}{2}$	2	$\frac{5}{2}$	${}^2D_{5/2}$	3.55	1.83	1.73
Zn ²⁺	3d ¹⁰	0	0	0	1S_0	0	0	0

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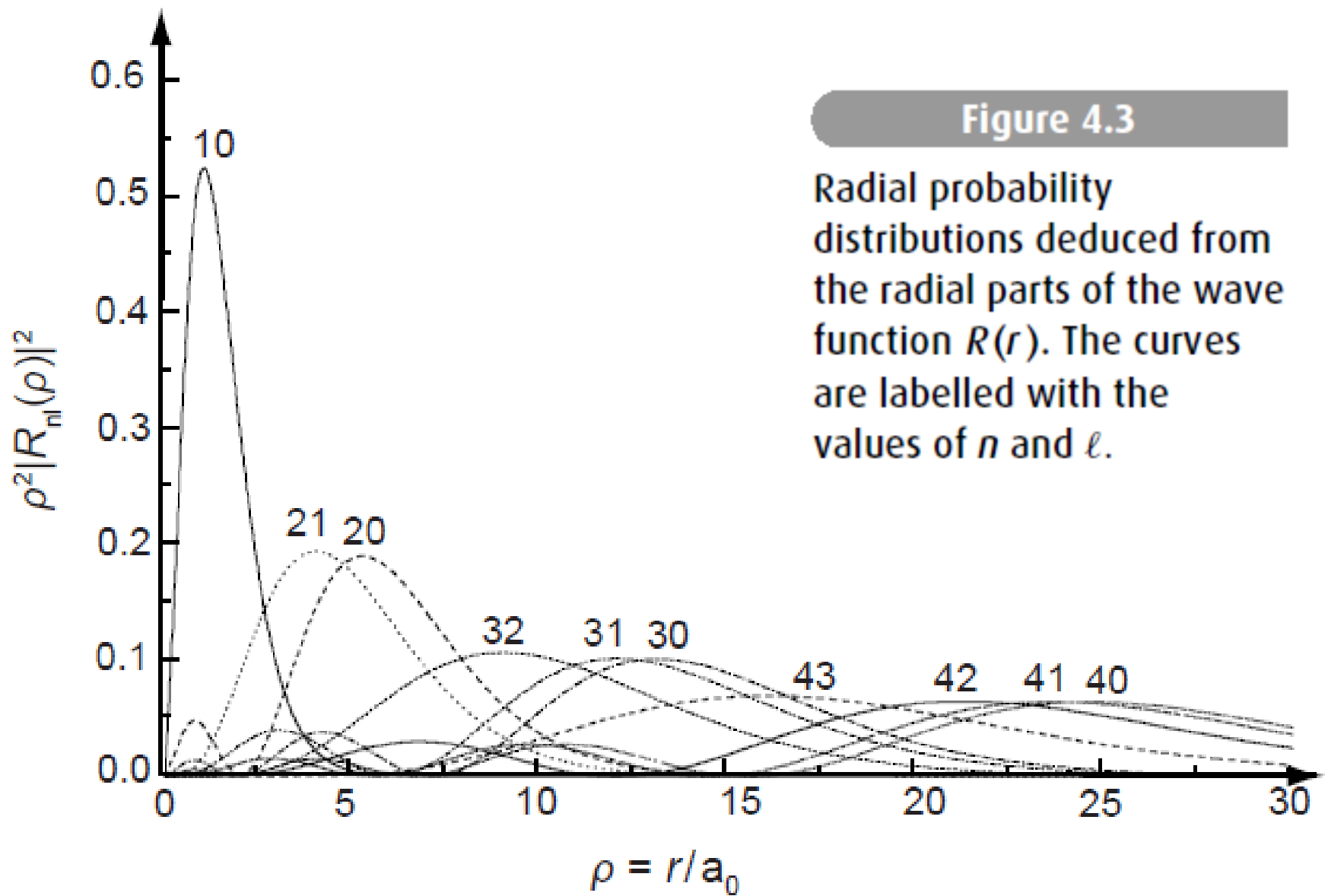


Figure 4.3

Radial probability distributions deduced from the radial parts of the wave function $R(r)$. The curves are labelled with the values of n and ℓ .