Ch. 9. Atomic Structure

이 병 호
서울대 전기공학부
byoungho@snu.ac.kr

Orbital Magnetism

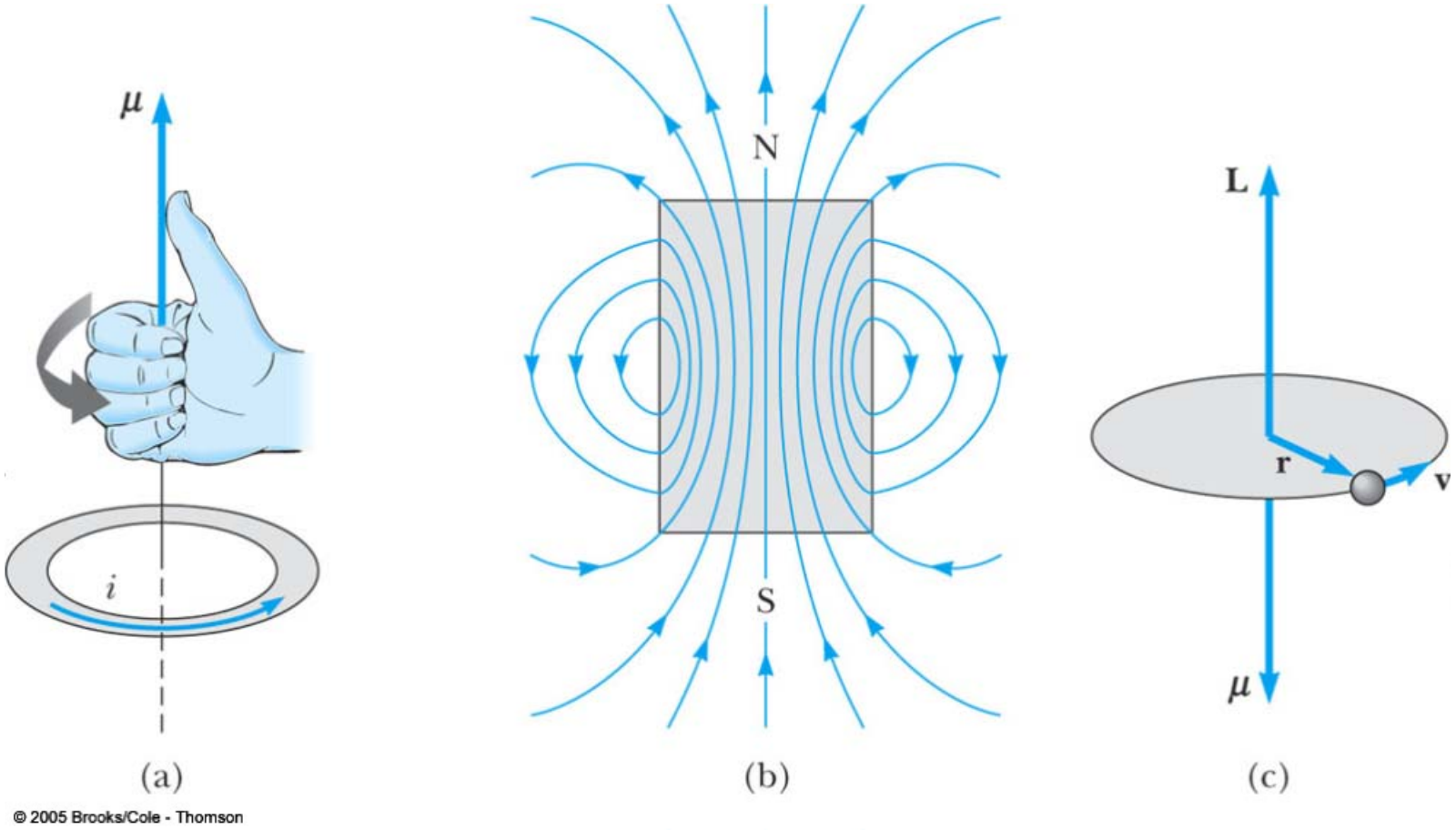


Fig. 9-1, p.296

Torque

$$\mathbf{L} = \mathbf{r} \times \mathbf{p}$$

$$\mathbf{F} = \frac{d\mathbf{p}}{dt}$$

$$\boldsymbol{\tau} = \mathbf{r} \times \mathbf{F} = \frac{d\mathbf{L}}{dt}$$

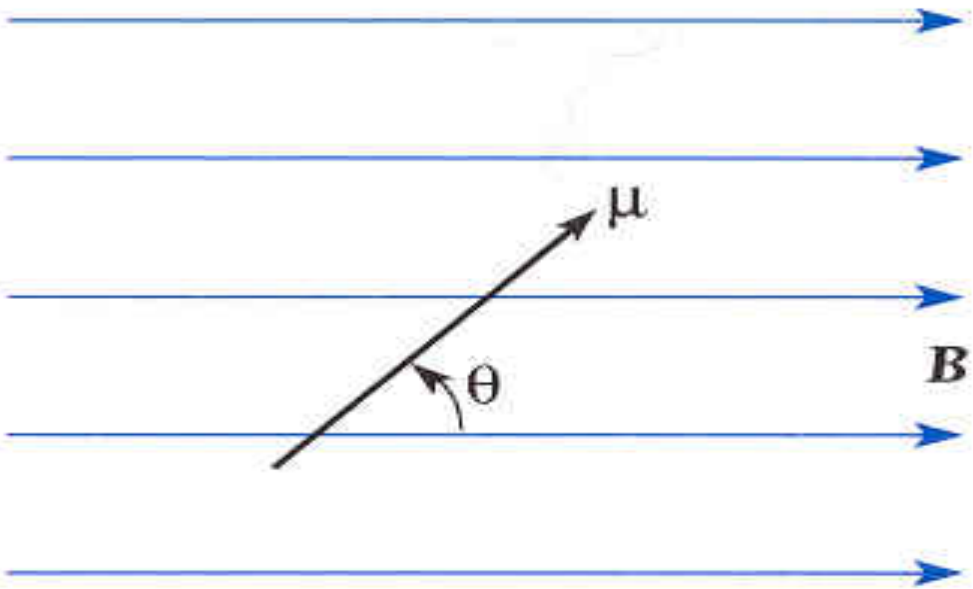


Figure 6.15 A magnetic dipole of moment $\boldsymbol{\mu}$ at the angle θ relative to a magnetic field $\boldsymbol{B}$.

$$\boldsymbol{\tau} = \boldsymbol{\mu} \times \mathbf{B}$$

$$U = -\boldsymbol{\mu} \cdot \mathbf{B}$$

$$\boldsymbol{\mu} = \frac{q}{2m}\mathbf{L}$$

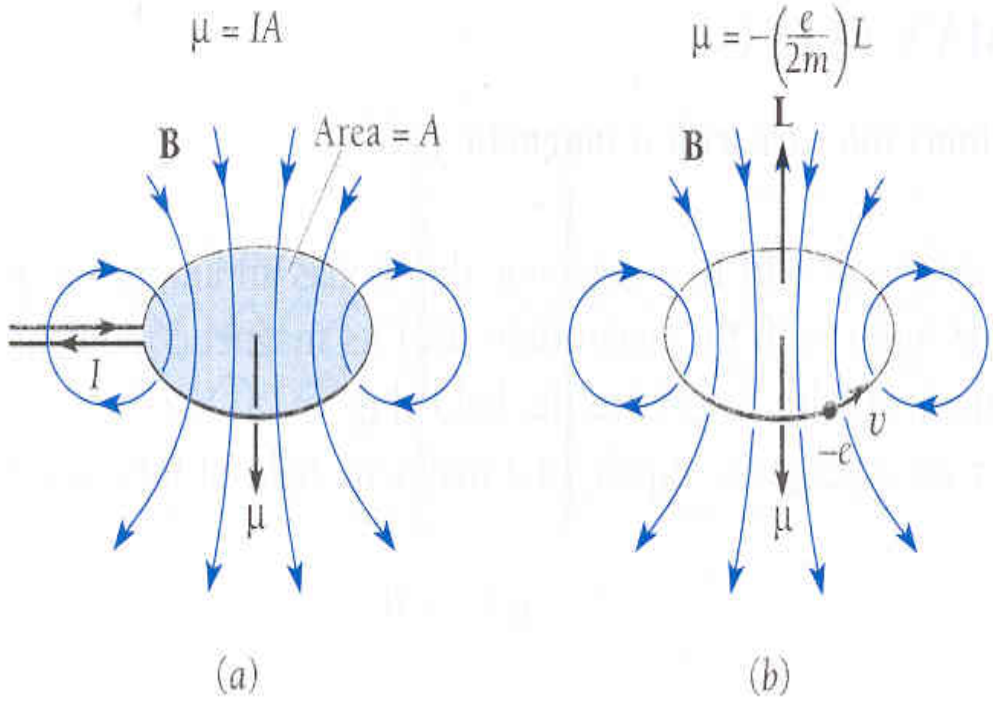
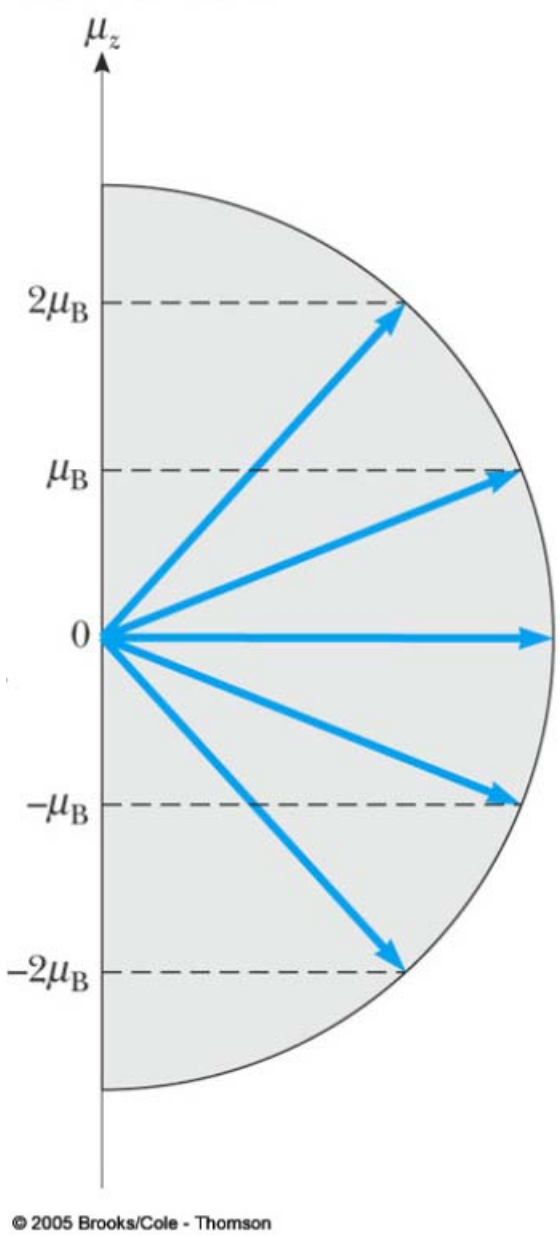


Figure 6.16 (*a*) Magnetic moment of a current loop enclosing area *A*. (*b*) Magnetic moment of an orbiting electron of angular momentum **L**.



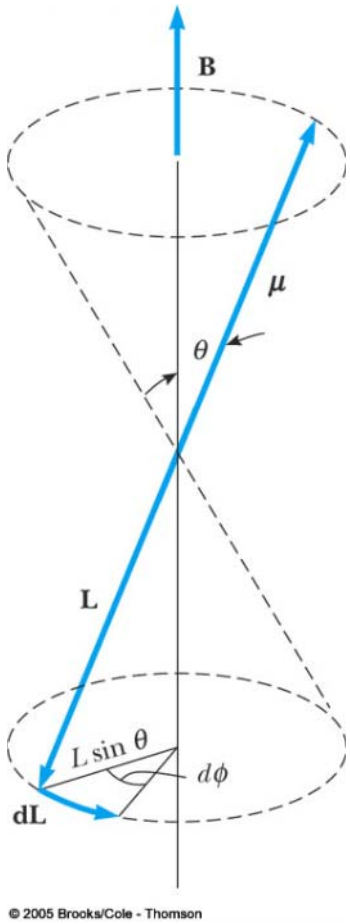
$$\mu_z = -\frac{e}{2m_e} L_z$$

$$= -\frac{e\hbar}{2m_e} m_l = -\mu_B m_l$$

$$\mu_B = \frac{e\hbar}{2m_e}$$ Bohr magneton

Fig. 9-2, p.298

Larmor Precession



$$|d\mathbf{L}| = L\sin\theta\, d\phi$$

$$|d\mathbf{L}| = |\boldsymbol{\tau}|\,dt = |\mu B\sin\theta|\,dt = \left|\frac{q}{2m}LB\sin\theta\right|dt$$

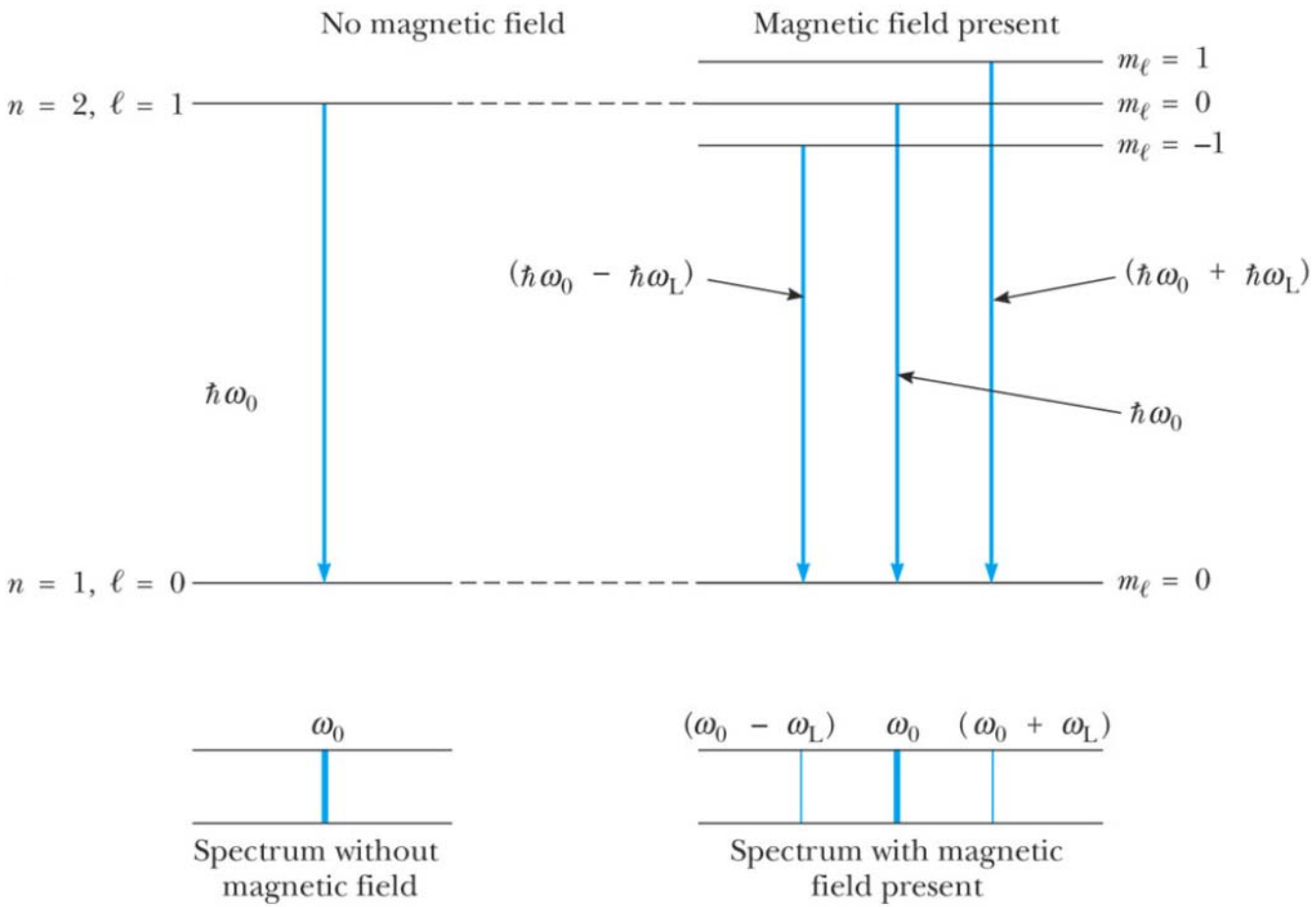
Larmor frequency

$$\omega_{\mathrm{L}} = \frac{d\phi}{dt} = \frac{1}{L\sin\theta}\frac{|d\mathbf{L}|}{dt} = \frac{e}{2m_e}B$$

$$U = -\boldsymbol{\mu}\cdot\mathbf{B} = \frac{e}{2m_e}\mathbf{L}\cdot\mathbf{B} = \frac{eB}{2m_e}L_z = \hbar\omega_L m_l$$

Fig. 9-3, p.298

Normal Zeeman Effect



$$E = E_0 + \hbar\omega_L m_l$$

Fig. 9-4, p.300

Normal Zeeman Effect

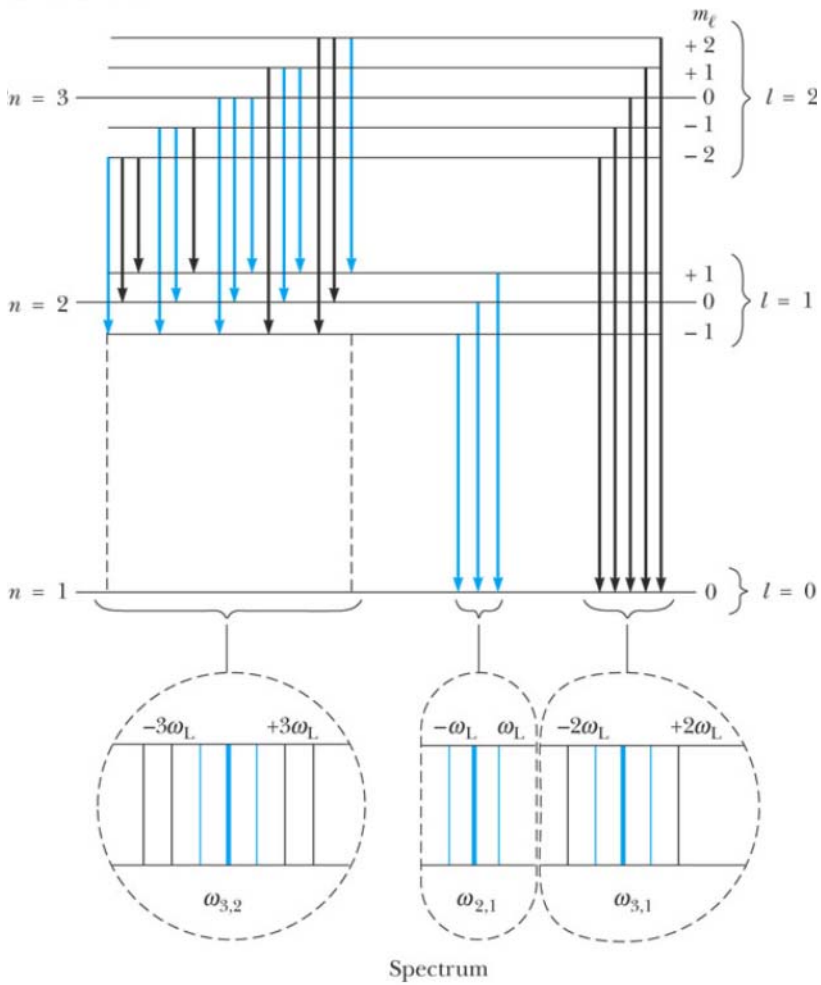


Fig. 9-5, p.301

Normal and Anomalous Zeeman Effect

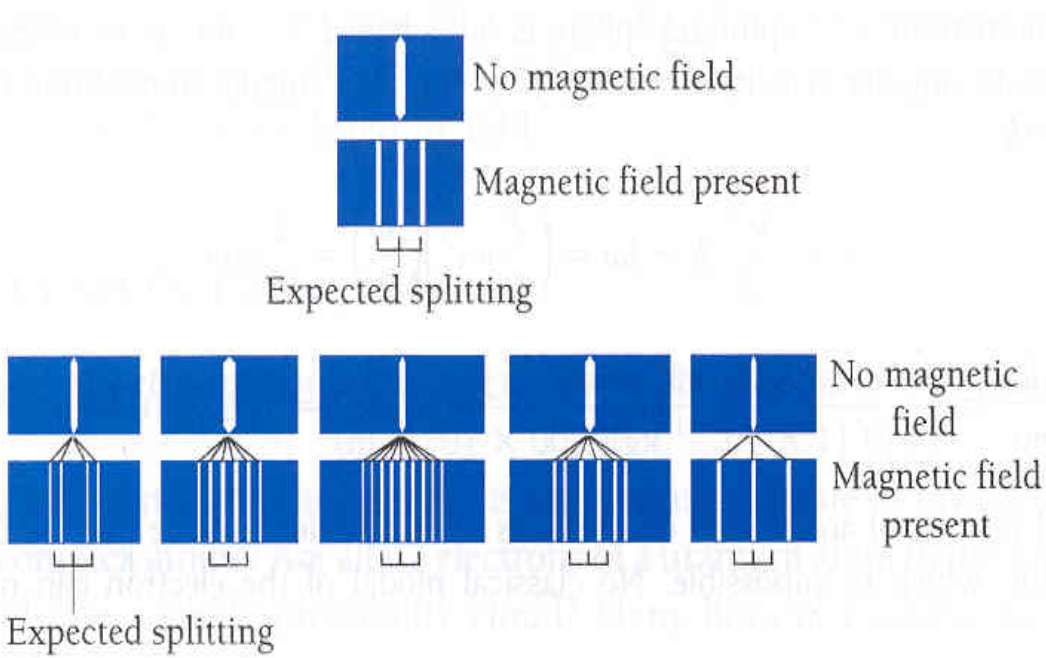
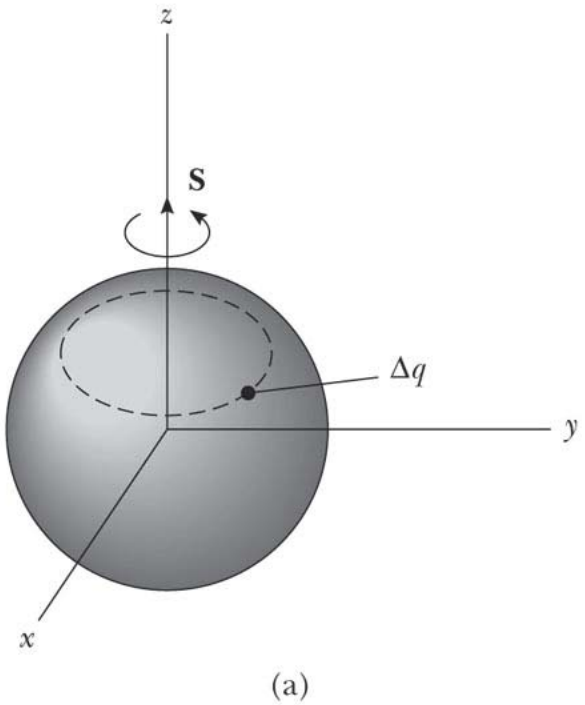
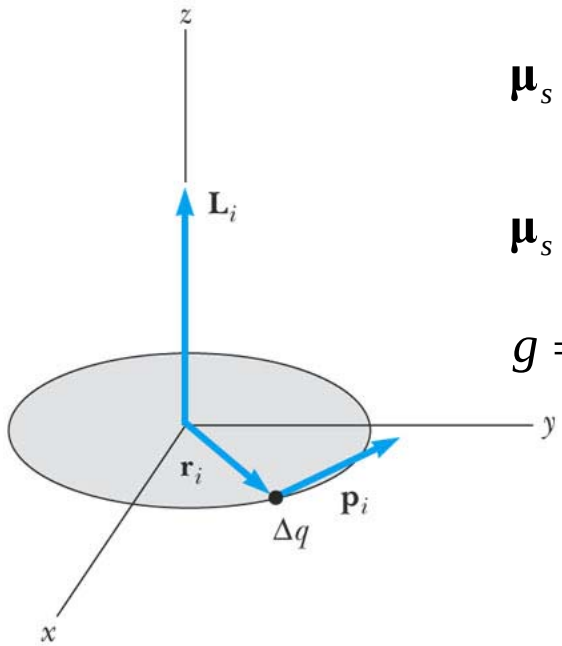


Figure 7.1 The normal and anomalous Zeeman effects in various spectral lines.

Spin – Classical Analogy





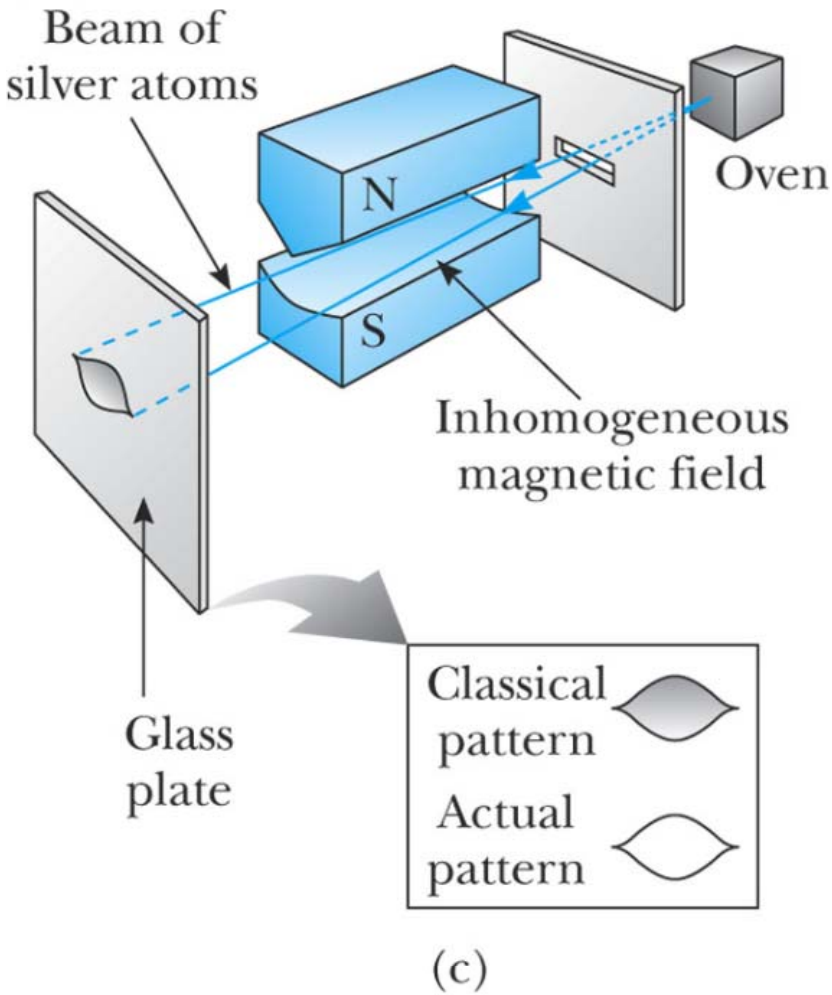
$$\boldsymbol{\mu}_s = \frac{q}{2m_e}\sum \mathbf{L}_i = \frac{q}{2m_e}\mathbf{S}$$

$$\boldsymbol{\mu}_s = \frac{-e}{2m_e} g\mathbf{S}$$

$$g = 2$$

Fig. 9-6, p.302

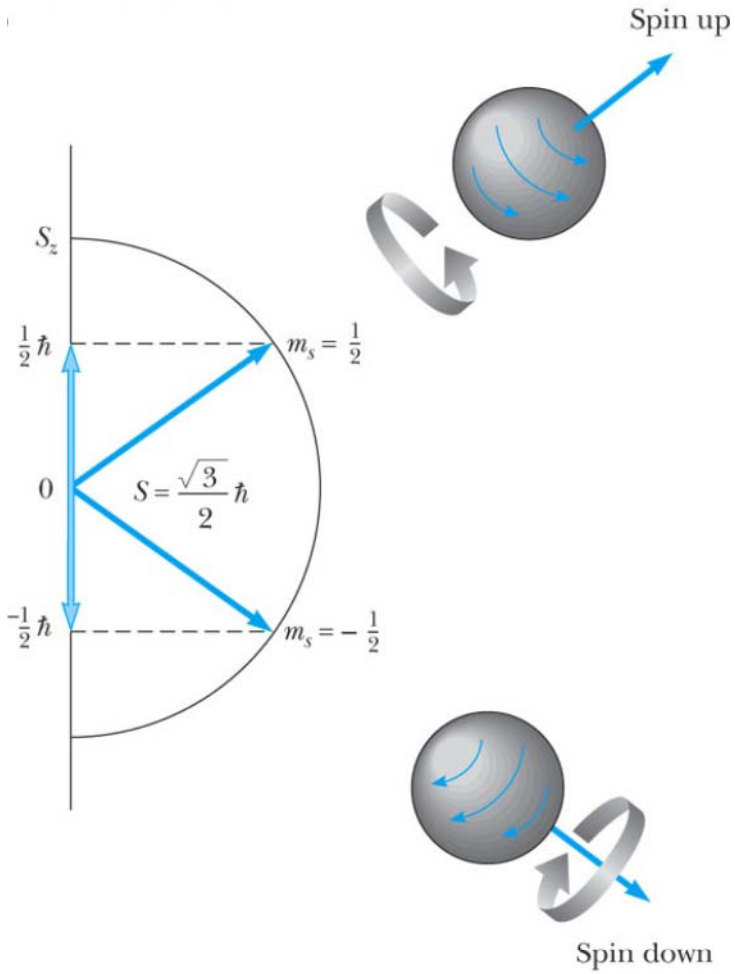
Stern-Gerlach Experiment



(c)

Fig. 9-7c, p.305

Spin



$$s = \frac{1}{2}$$

$$m_s = -\frac{1}{2},\ \frac{1}{2}$$

$$S = \sqrt{s(s+1)}\hbar = \frac{\sqrt{3}}{2}\hbar$$

$$S_z = m_s\hbar = -\frac{\hbar}{2},\ \frac{\hbar}{2}$$

Fig. 9-8, p.306

Table 7.1 Quantum Numbers of an Atomic Electron

Name	Symbol	Possible Values	Quantity Determined
Principal	n	$1, 2, 3, \ldots$	Electron energy
Orbital	l	$0, 1, 2, \ldots, n-1$	Orbital angular-momentum magnitude
Magnetic	m_l	$-l, \ldots, 0, \ldots, +l$	Orbital angular-momentum direction
Spin magnetic	m_s	$-\frac{1}{2}, +\frac{1}{2}$	Electron spin direction

$$\boldsymbol{\mu} = \boldsymbol{\mu}_o + \boldsymbol{\mu}_s = \frac{-e}{2m_e}\left(\mathbf{L} + g\mathbf{S}\right) \qquad U = -\boldsymbol{\mu}\cdot\mathbf{B}$$

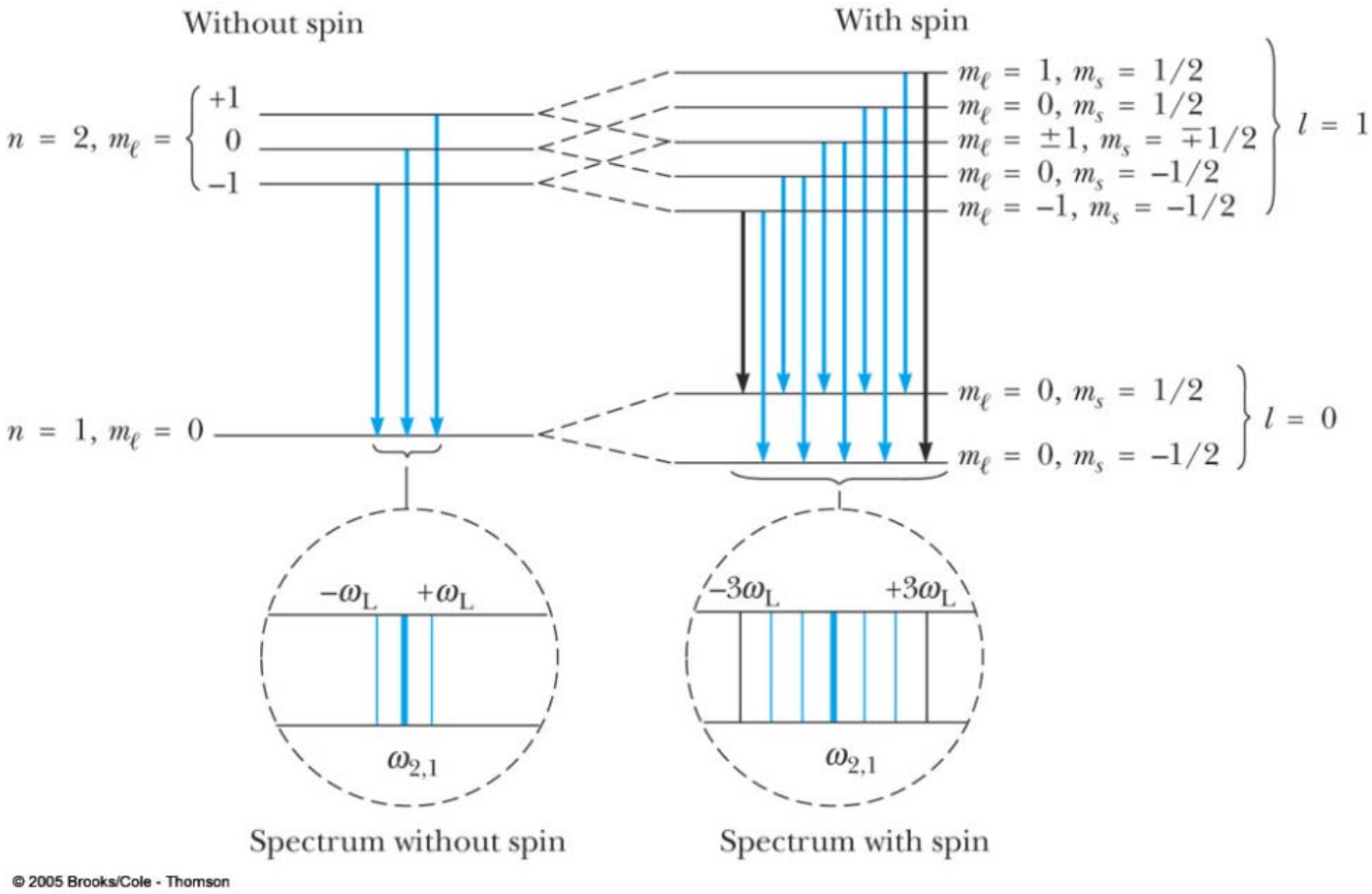
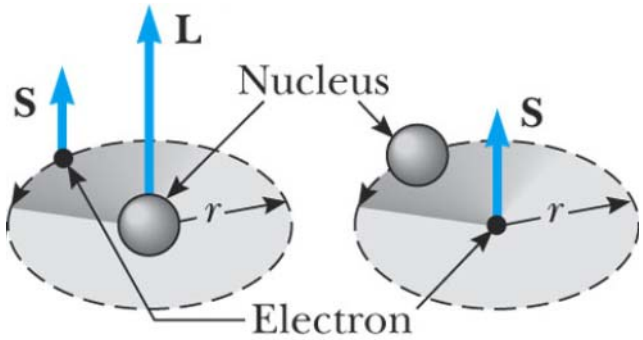
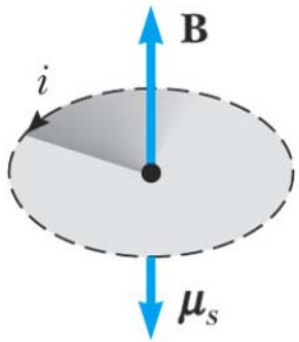


Fig. 9-9, p.308

Spin-Orbit Interaction



(a)



(b)

Fig. 9-10, p.310

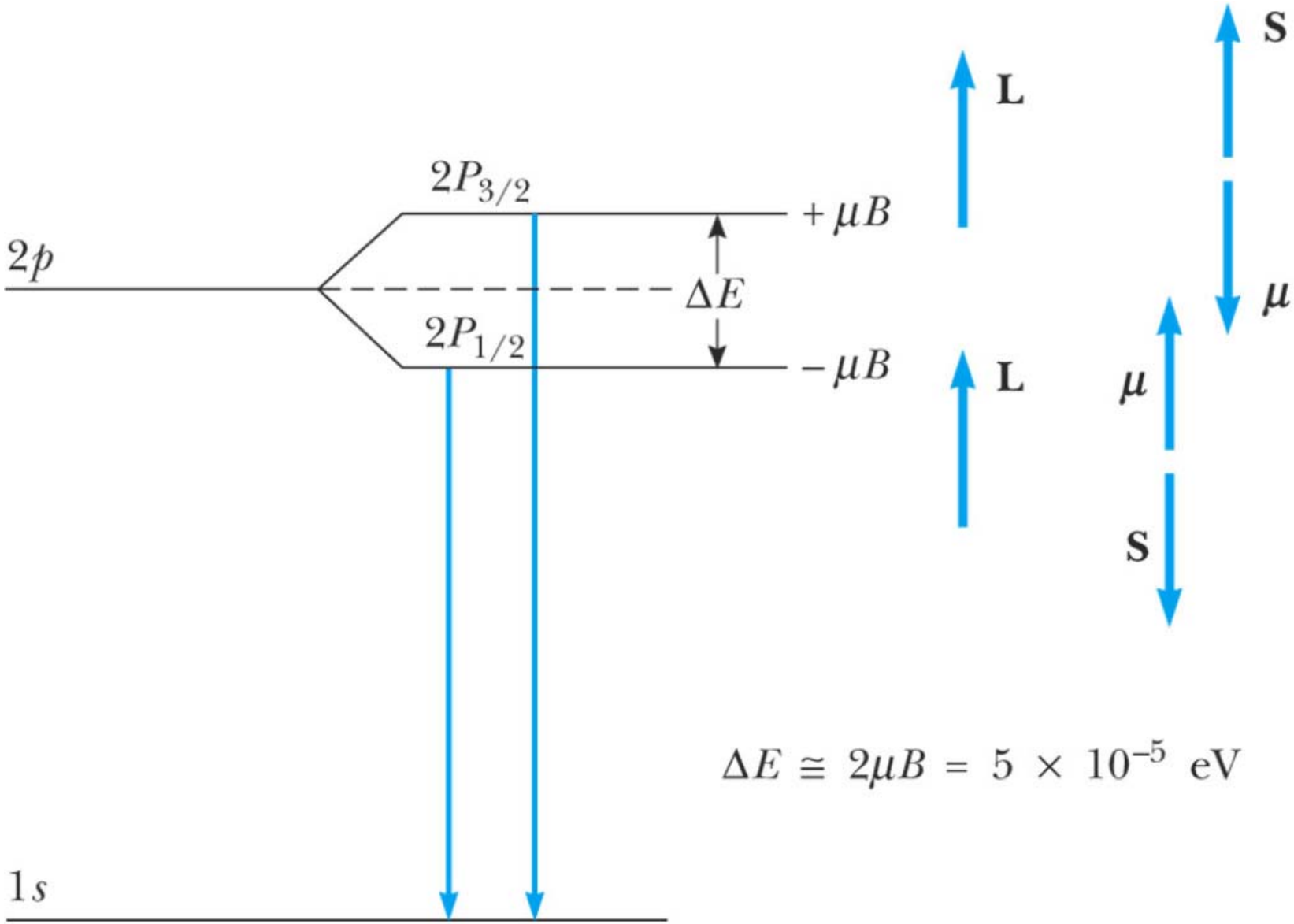


Fig. 9-11, p.310

$$\mathbf{J} = \mathbf{L} + \mathbf{S}$$

$$J = \sqrt{j(j+1)}\hbar$$

$$J_z = m_j \hbar \qquad \text{with } m_j = j,\ j-1,\ \cdots,\ -j$$

$$j = l+s,\ l+s-1,\ \cdots,\ |l-s|$$

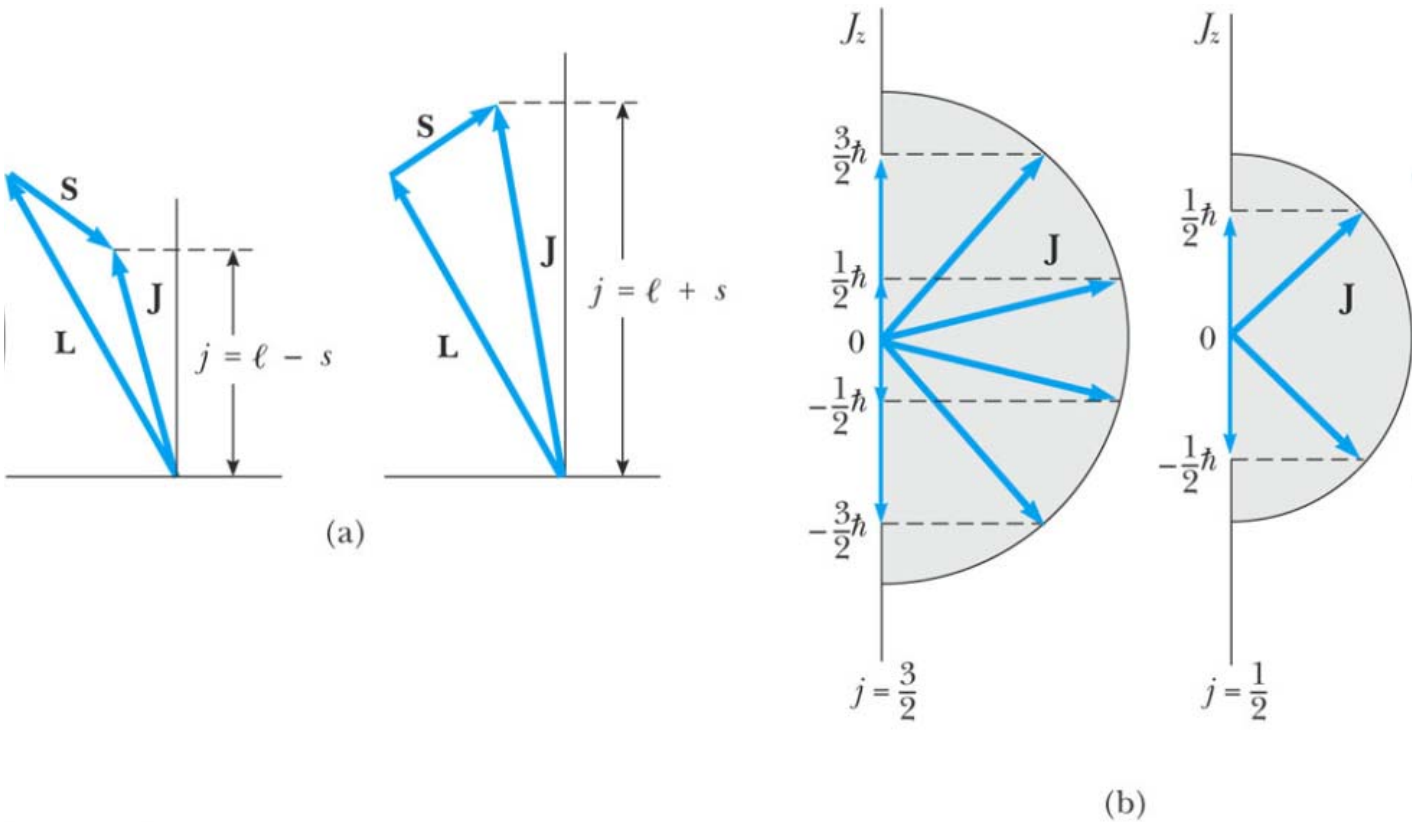


Fig. 9-12, p.310