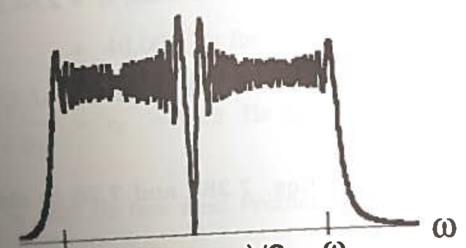
7.8 (a) See Figure 7.22 (bottom left). For more details, see: A. G. Marshall, T.-C. L. Wang & T. L. Ricca, *Chem. Phys. Lett.* **1984**, *105*, 233-236.

(b)



Chapter 8

Fourier transform nuclear magnetic resonance spectroscopy

8.1 Natural motion of a magnetic moment in a magnetic field: Larmor precession

8.1.1 Classical mechanical motion and energy of a magnetic moment in a static magnetic field: laboratory and rotating frame representations

Fourier transform nuclear magnetic resonance (FT/NMR) spectroscopy has been regularly and extensively reviewed and is the sole subject of more than a dozen monographs (see Further Reading). We will therefore limit this chapter to an introduction to some basic principles, followed by some representative nuclear spin manipulations and applications.

The fundamental concepts for a classical mechanical description of NMR are shown in Figure 8.1 and expressed algebraically in Eqs. 8.1 and 8.2. First, a static magnetic field, $\boldsymbol{B}_0$ (in tesla), acting on a classical mechanical bar magnet with magnetic (dipole) moment, μ (in ampere m^{-2}) produces a *torque* (kg m^2 s^{-2}) given by Eq. 8.1.

$$\text{Torque} = \frac{d\boldsymbol{I}}{dt} = \mu \times \boldsymbol{B}_0 \qquad (8.1)$$

in which $\boldsymbol{I}$ is the angular momentum associated with the moving bar magnet.

Second, a classical mechanical magnetic field is generated by charges in motion. Thus, it is natural to find that the magnitude (and direction) of a magnetic (dipole) moment, μ, is proportional to the magnitude of the angular momentum, $\boldsymbol{I}$, of a spinning charge distribution:

$$\mu = \gamma \boldsymbol{I} \qquad (8.2)$$

in which the proportionality constant, γ, is called the *magnetogyric ratio.* Eqs. 8.1 and 8.2 may be combined to yield the equation of motion for a bar magnet in a static magnetic field:

$$\frac{d\mu}{dt} = \gamma\mu \times \boldsymbol{B}_0 \qquad (8.3)$$

Since the "strength" of a bar magnet (i.e., the length of the μ vector) is constant, the motion described by Eq. 8.3 is simply a *precession* of μ at angular velocity, ω_0, about $\boldsymbol{B}_0$, as shown in Figure 8.1 and described algebraically by Eq. 8.4.