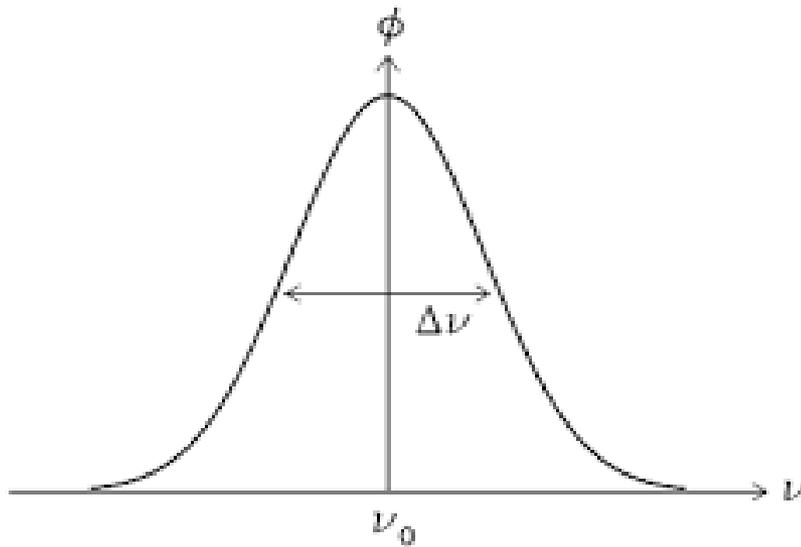




**WIDTH OF  
SPECTRAL LINES  
AND  
HYPERFINE  
STRUCTURE**

# WIDTH OF SPECTRAL LINES

- FULL WIDTH AT HALF MAXIMUM(FWHM)





# REASONS:

1) NATURAL LINE WIDTH

2) DOPPLER BROADENING

3) COLLISION BROADENING

# 1) NATURAL LINE WIDTH

ENERGY LEVELS ARE NOT  
PRECISELY DETERMINED

$$E_2 - E_1 = \Delta E$$

$$\Delta E = h\Delta\nu$$

Uncertainty principle, Energy level above ground state with energy  $E$  and lifetime  $\Delta t$ , has uncertainty in energy:

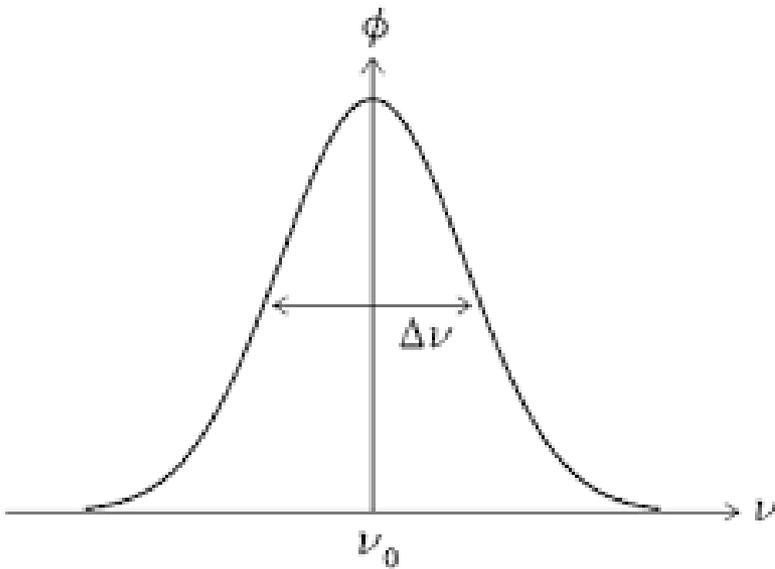
$$\Delta E \Delta t \sim \hbar$$

ie short-lived states have large uncertainties in the energy.

- A photon emitted in a transition from this level to the ground state will have a range of possible frequencies,

$$\Delta \nu \sim \Delta E/h \sim 1/(2\pi\Delta t)$$

# LORENTZIAN PROFILE



- DECAY RATE:

$$\gamma = \sum A_{nn'}$$

$$\Phi(\nu) = \frac{\gamma / 4\pi^2}{(\nu - \nu_0)^2 + (\gamma / 4\pi)^2}$$

## 2) DOPPLER BROADENING

FREQUENCY OF EMITTED RADIATION  
DEPENDS ON VELOCITY OF SOURCE  
RELATIVE TO THAT OF OBSERVER.

WAVELENGTH OBSERVED BY THE  
OBSERVER:

$$\text{➤ } \Lambda = \Lambda_0 + (1 + v/c)$$

# 3) COLLISION BROADENING

- COLLISION BETWEEN MOLECULES PERTURBS ENERGIES OF AN ATOMIC SYSTEM
- DEPENDS ON
  1. PRESSURE
  2. DENSITY
  3. TEMPERATURE
  4. NATURE OF MOLECULE

- 
- SPECTRAL LINES OF GASEOUS SAMPLES ARE MORE **SHARPER** THAN THAT OF LIQUIDS

# **HYPERFINE STRUCTURE OF SPECTRAL LINES**

# HYPERFINE STRUCTURE:

INDIVIDUAL MULTIPLY  
CONSIST OF A NUMBER OF LINES

ATOMIC NUCLEUS IS RESPONSIBLE FOR THE  
SPLITTING

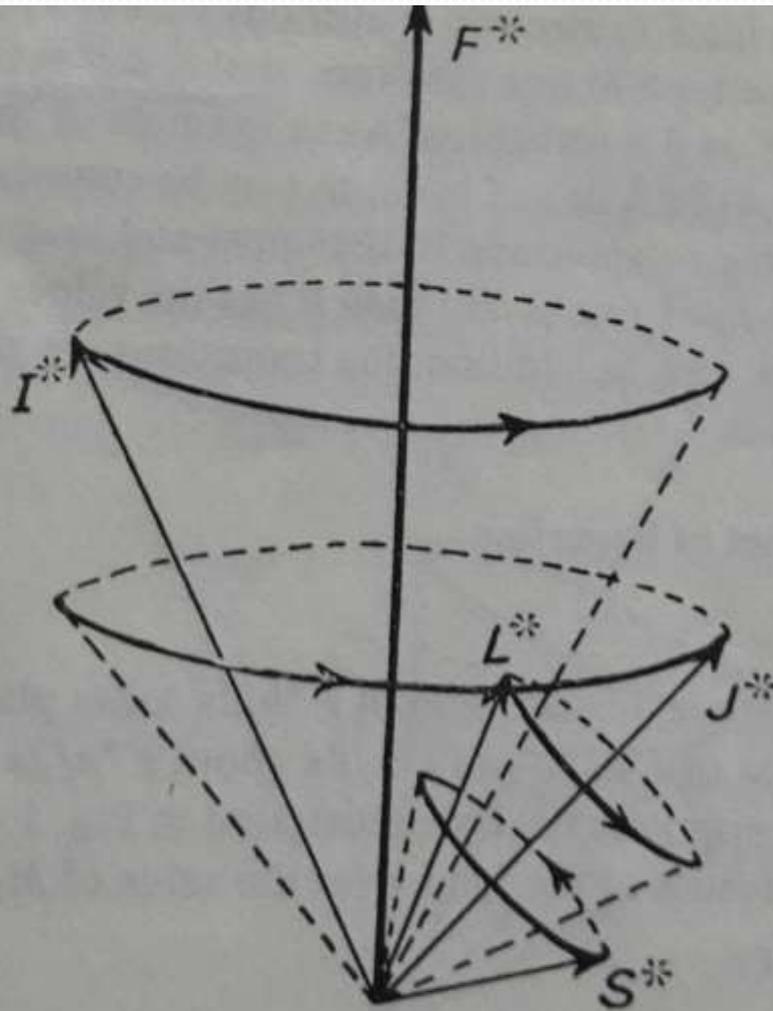


Fig. 1.43 Precession of  $L^*h/2\pi$  and  $S^*h/2\pi$  about their resultant  $J^*h/2\pi$  and the precession of  $J^*h/2\pi$  and  $I^*h/2\pi$  about their resultant  $F^*h/2\pi$ . The vectors are in  $h/2\pi$ .

**$I^*$  = NUCLEAR ANGULAR MOMENTUM**

**$J^*$  = ELECTRONIC ANGULAR MOMENTUM**  
(DUE TO COUPLING OF  $L^*$  &  $S^*$ )

**$I^*$  &  $J^*$  COUPLES TO GIVE RESULTANT  $F^*$**

**$F = J + I, J + I - 1, J + I - 2, \dots (J - I)$ .**

$$E_F = A/2 \{ F(F+1) - I(I+1) - J(J+1) \}$$

**A = Interaction Constant**

**$E_F$  = Interaction Energy**

**SELECTION RULE:  $\Delta F = 0, \pm 1$**



**THANK YOU!**