PHY127 FS2025

Prof. Ben Kilminster
Lecture 11
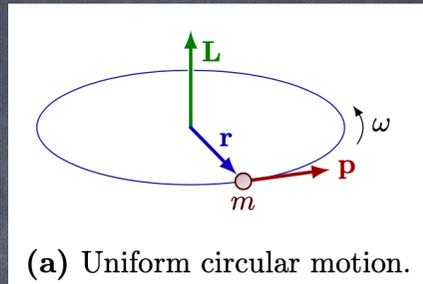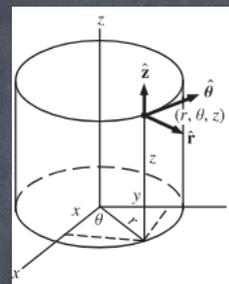May 16th, 2025

from PHY 117:
angular momentum
torque
magnetic moment

NMR → MRI
(spin precession of nuclei)
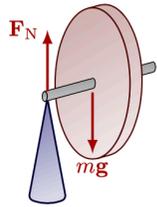
Angular momentum reminder

(a) Uniform circular motion.
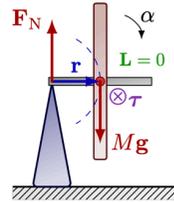
Interesting consequences
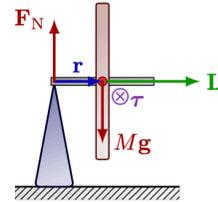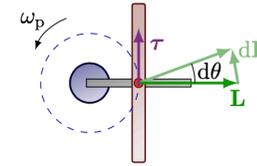
Interesting consequences

(a) The handle allows the disk to spin around its axis and around the pivot.

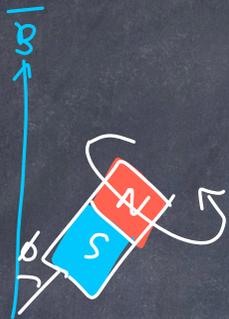**(b)** The disk does not spin, and it will fall down due to an unbalanced torque $\boldsymbol{\tau}$.

(c) The disk spins, creating an angular momentum $\mathbf{L}$. Torque $\boldsymbol{\tau}$ will cause a precession.
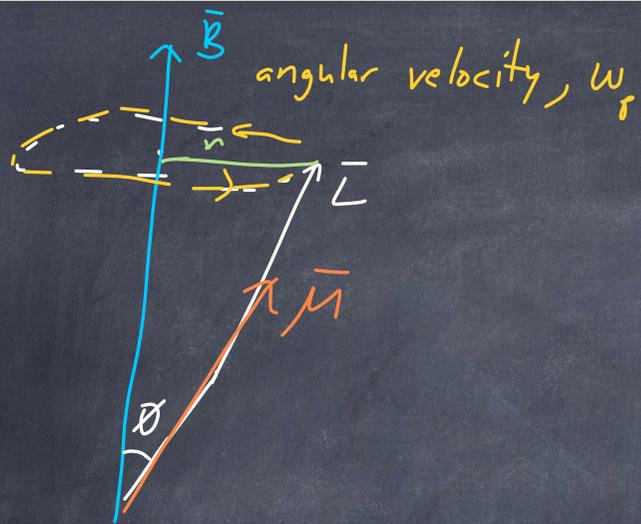
(d) Torque $\boldsymbol{\tau}$ perpendicular to angular momentum $\mathbf{L}$, will only change its direction.

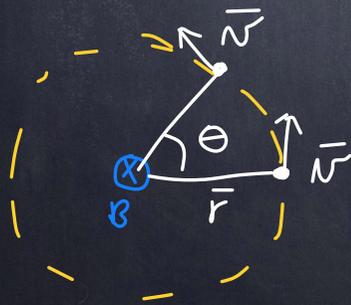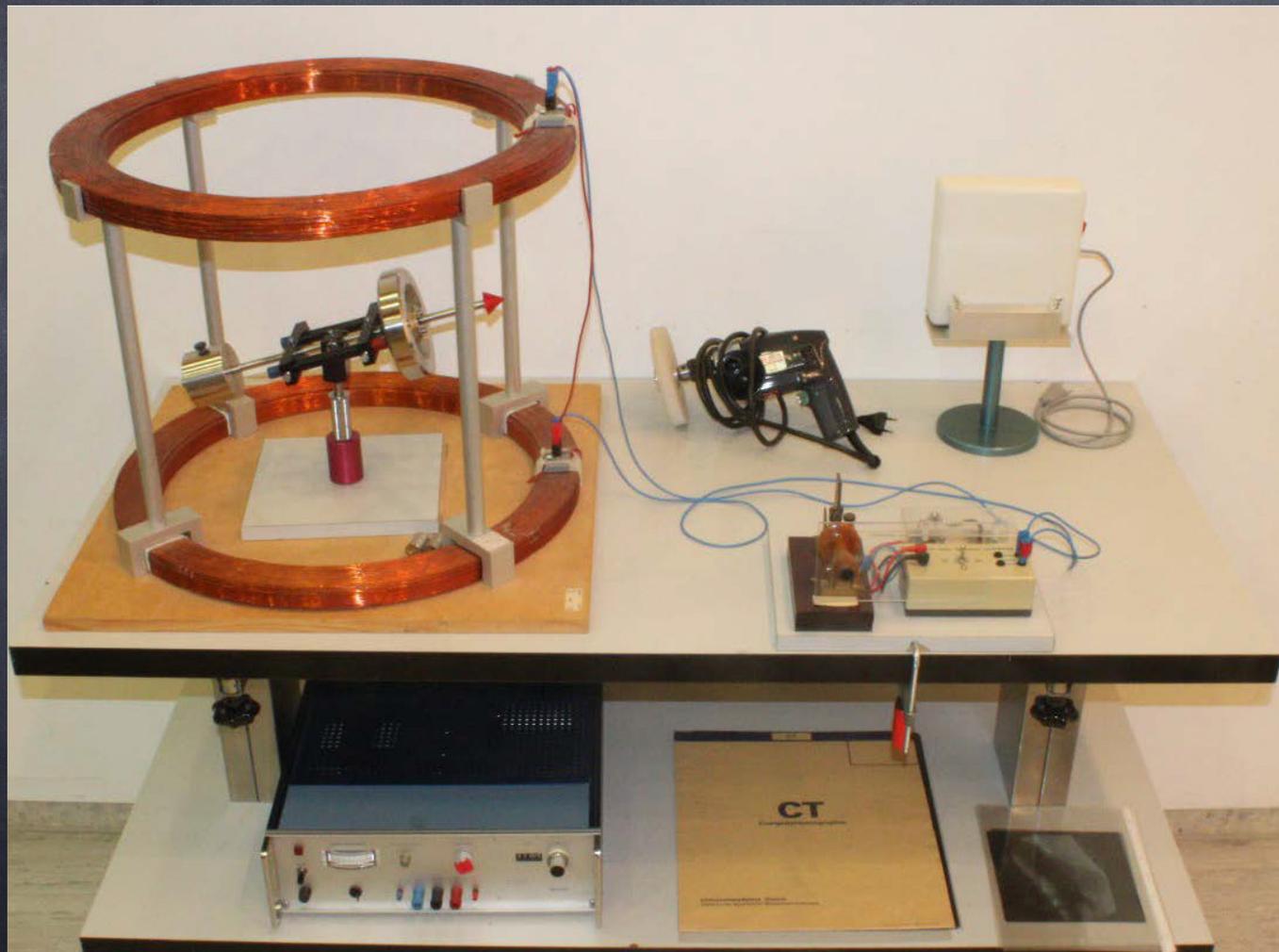The same effect occurs for a
magnet spinning in a magnetic field

$\bar{B}$

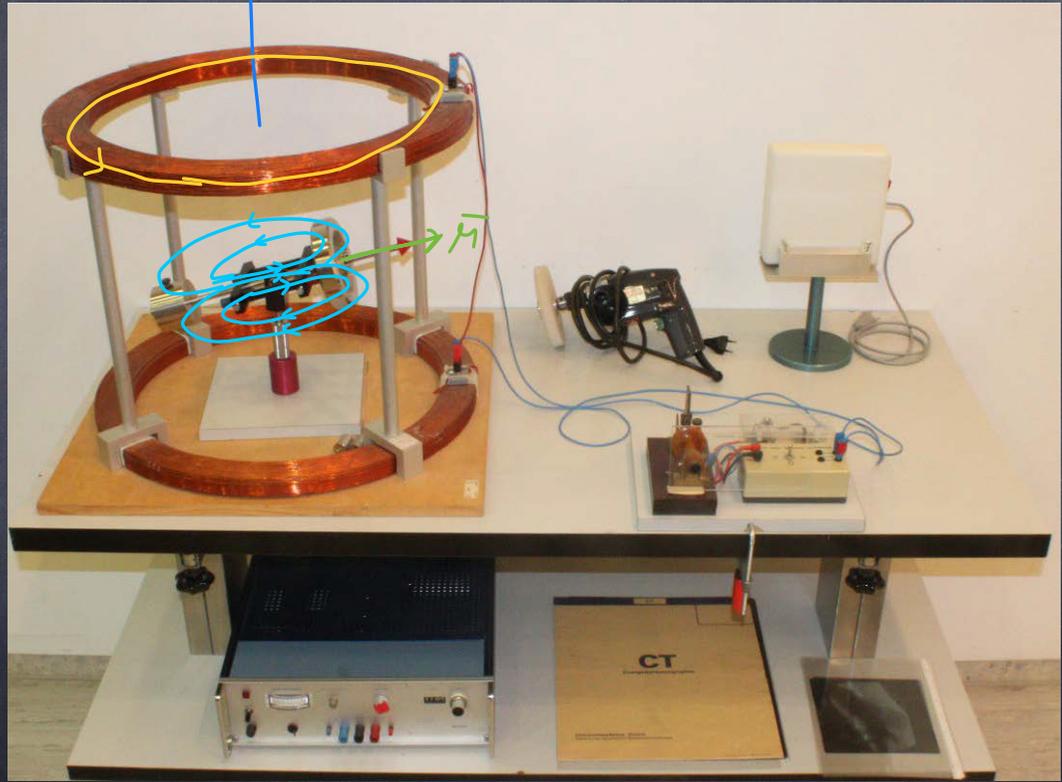angular velocity, ω_g

$\bar{L}$

r

$\eta \bar{\mu}$

ϕ

$r = \bar{L} \sin\phi$

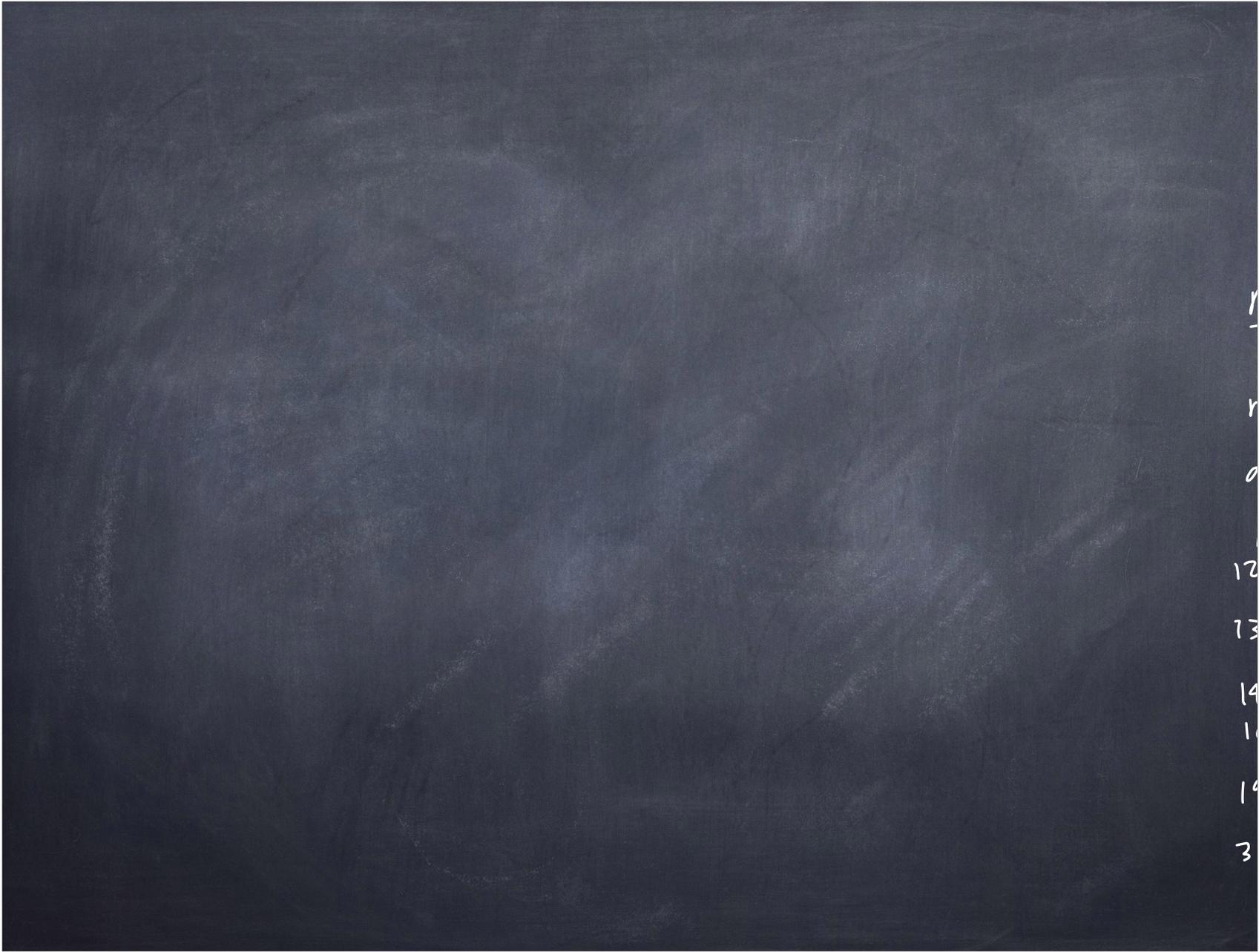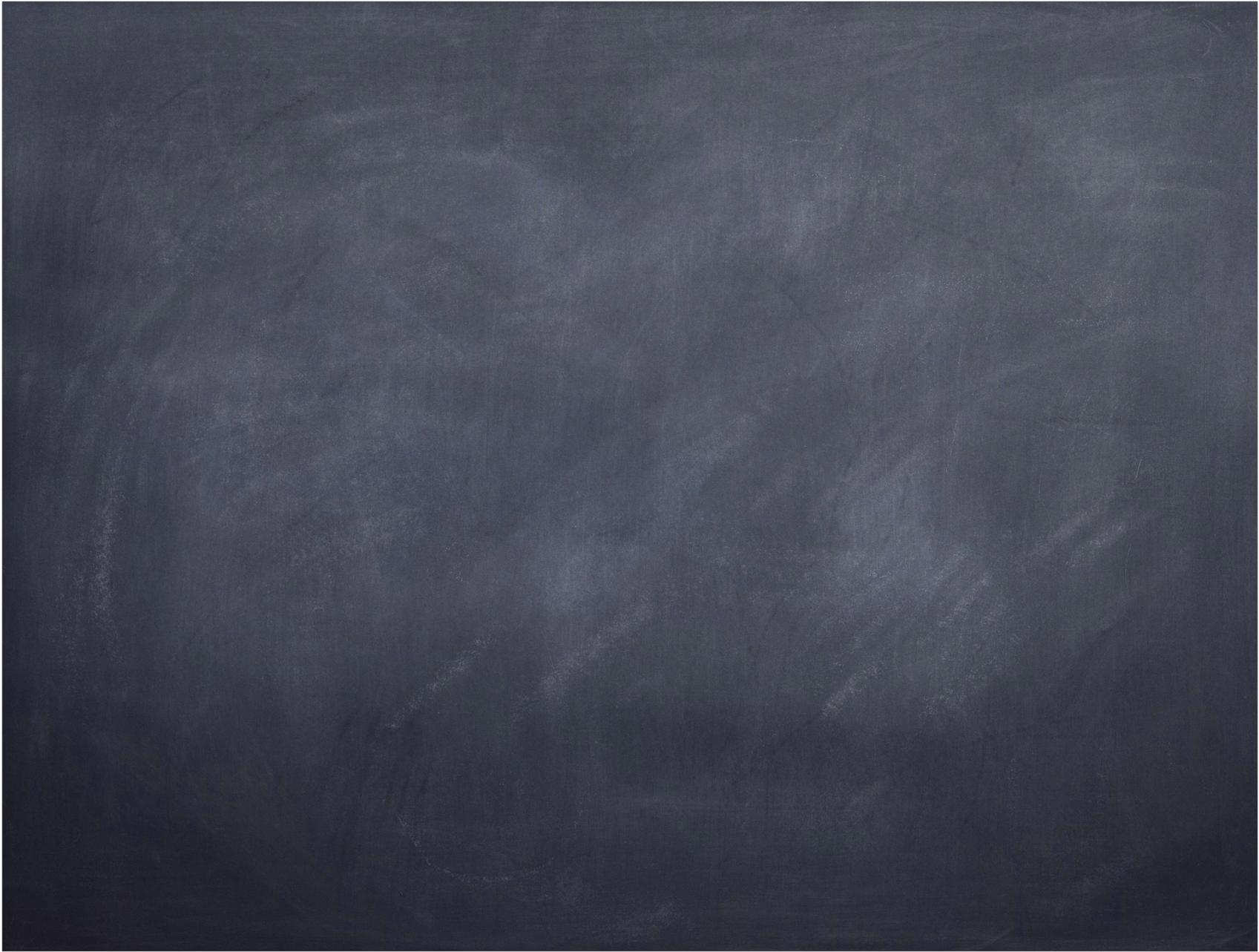$N = r \omega_p = \omega_p \bar{L} \sin\phi$

from above:

$\bar{N}$

θ

$\bar{N}$

$\otimes$

B

$\bar{r}$

$N = r \dfrac{d\theta}{dt} = r \omega_p$

9

In NMR, RF (radio frequency) is fixed and $\bar{B}$ is varied by small amounts while scanning through for resonance conditions. (see video on wikipedia page)

Einstein showed that the same RF photons that can be absorbed, flipping spins to a higher energy state, can with equal probability, flip the nuclear spin to a lower energy state, emitting a second RF photon with energy ΔE.

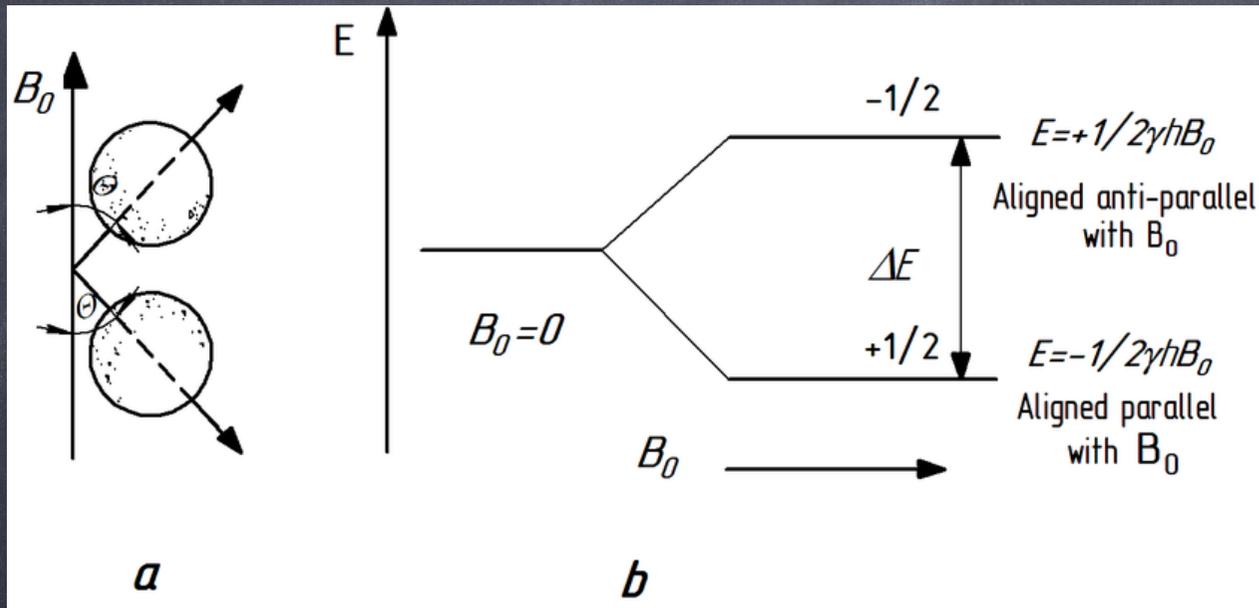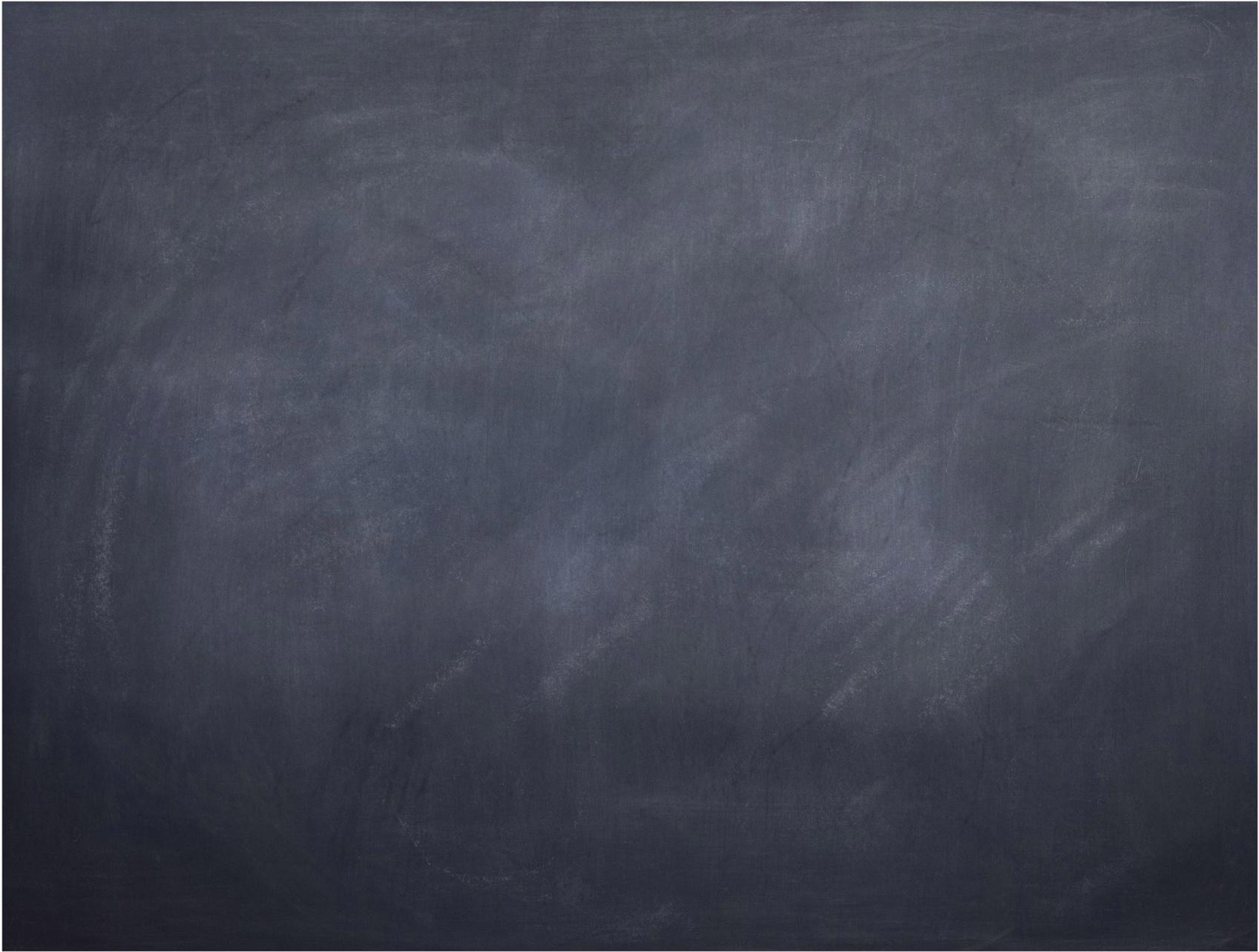If n_{up} & n_{down} were equal, there would be no net absorption. But, since there are slightly more nuclei in the n_{down} state than the n_{up} state, there is a slight net absorption of photons. this is our signal for NMR.

How to detect NMR radiation.

detector

recorder

N   sample   S

RF source

How to detect NMR radiation.

detector

recorder

RF source

N

sample

S

Sample is placed in
a magnetic field

detector is a solenoid
that can measure
changes in electric current

steps:

1) small amount of RF radiation
is absorbed by our sample,
then we turn off the RF.

2) The sample returns to equilibrium,
by emitting RF energy.

The net magnetic moment of the sample
changes, and this can be detected in the solenoidal
coil. (This comes from PHY 117 (script 2))
The changing magnetism of the sample
induces a electric current in the solenoid.)
(Faraday's Law)

Next time! how to use NMR to determine molecular structure

Ethanol