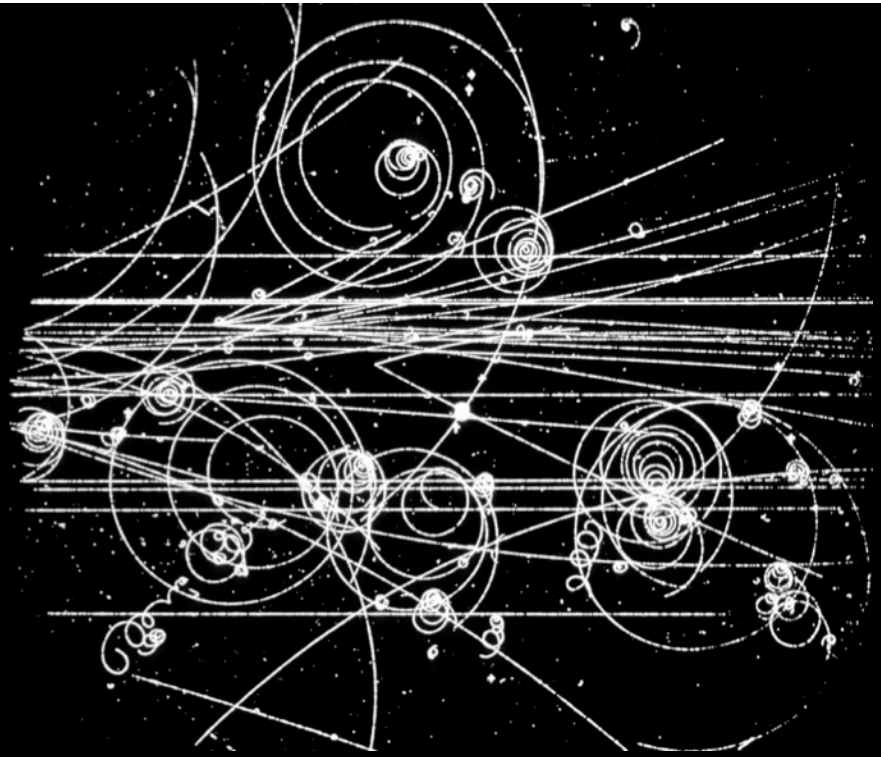
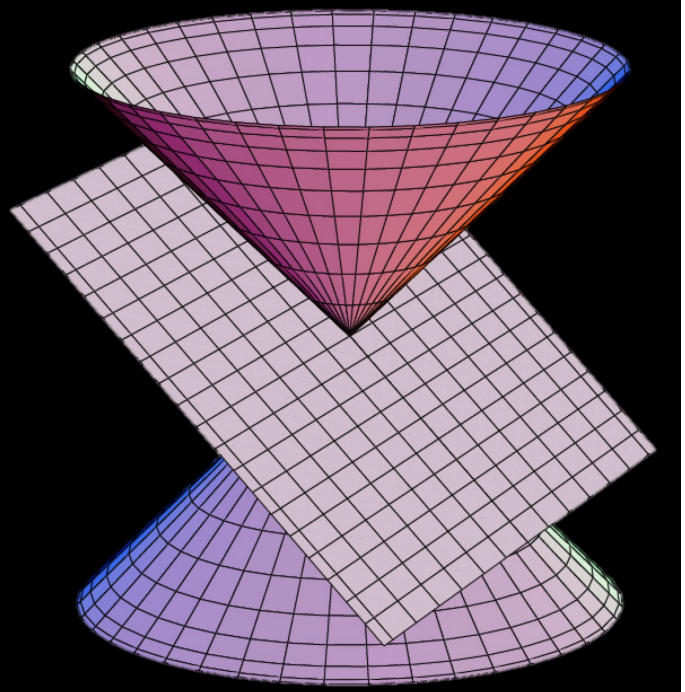




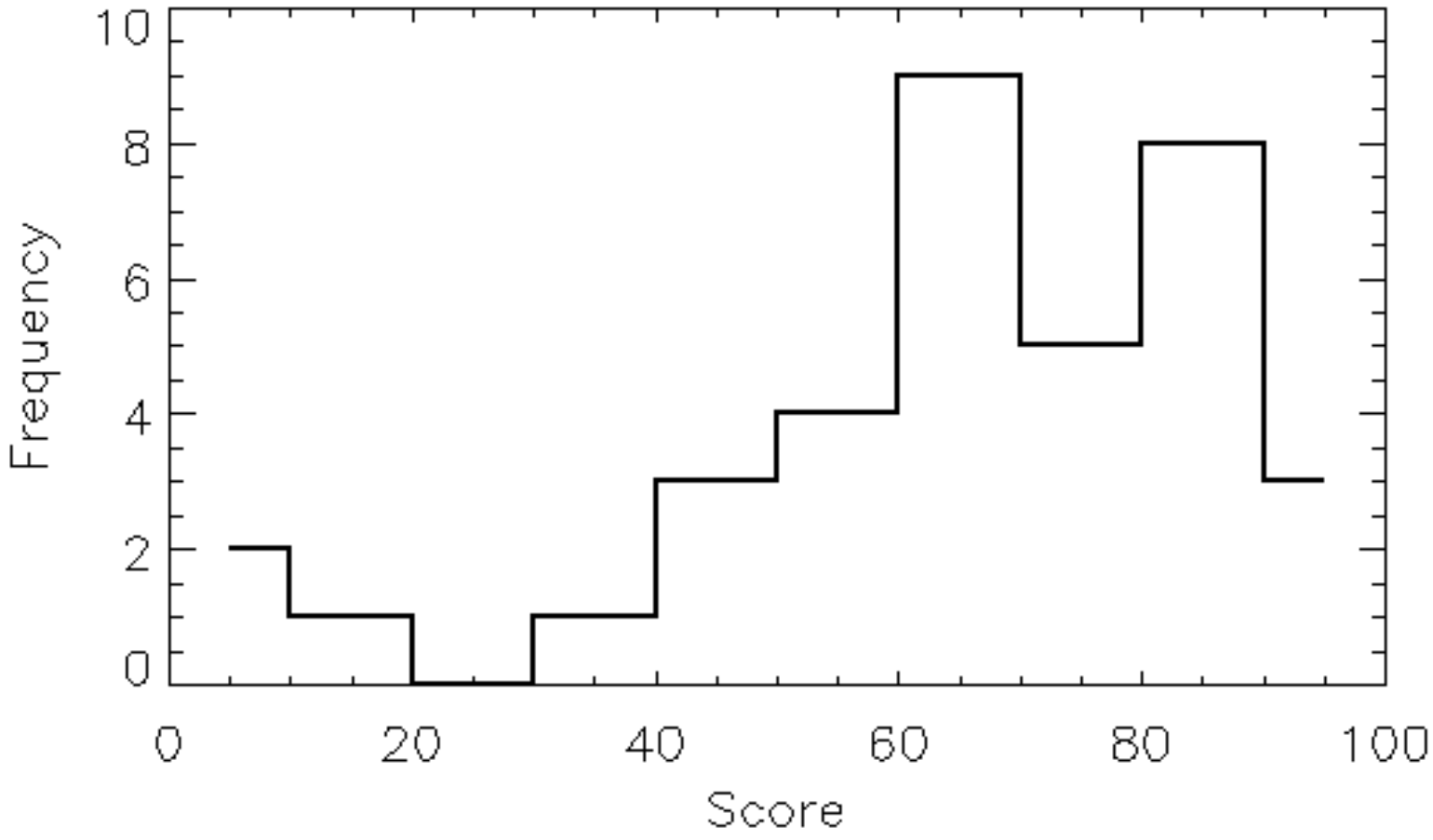
Modern Physics (Phys. IV): 2704

Professor Jasper Halekas
Van Allen 70
MWF 12:30-1:20 Lecture

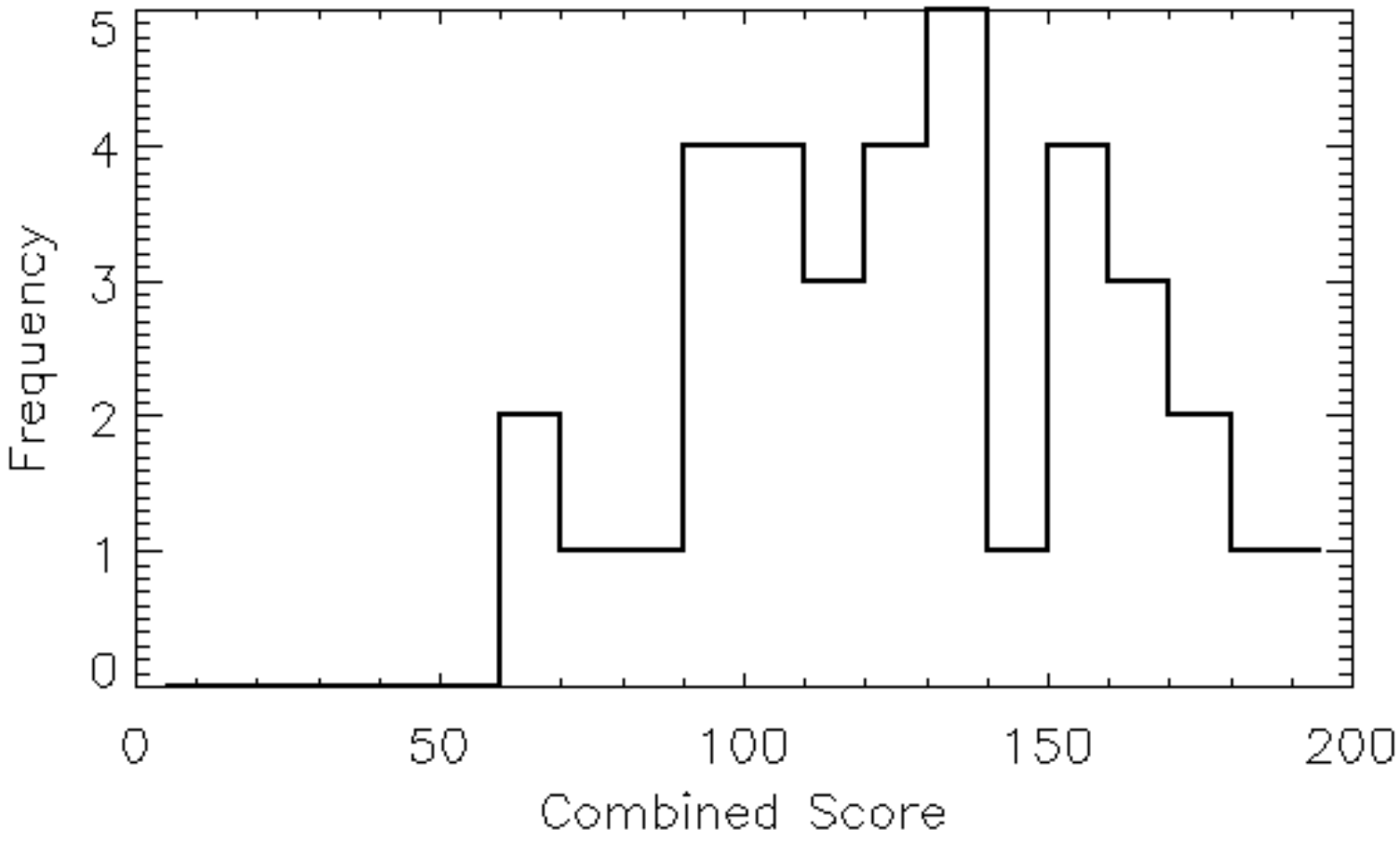
Midterm II Is a Wrap

- Mean of 34 people who took the test
  - 69/100
- Mean of entire class including 2 absentees
  - 65/100

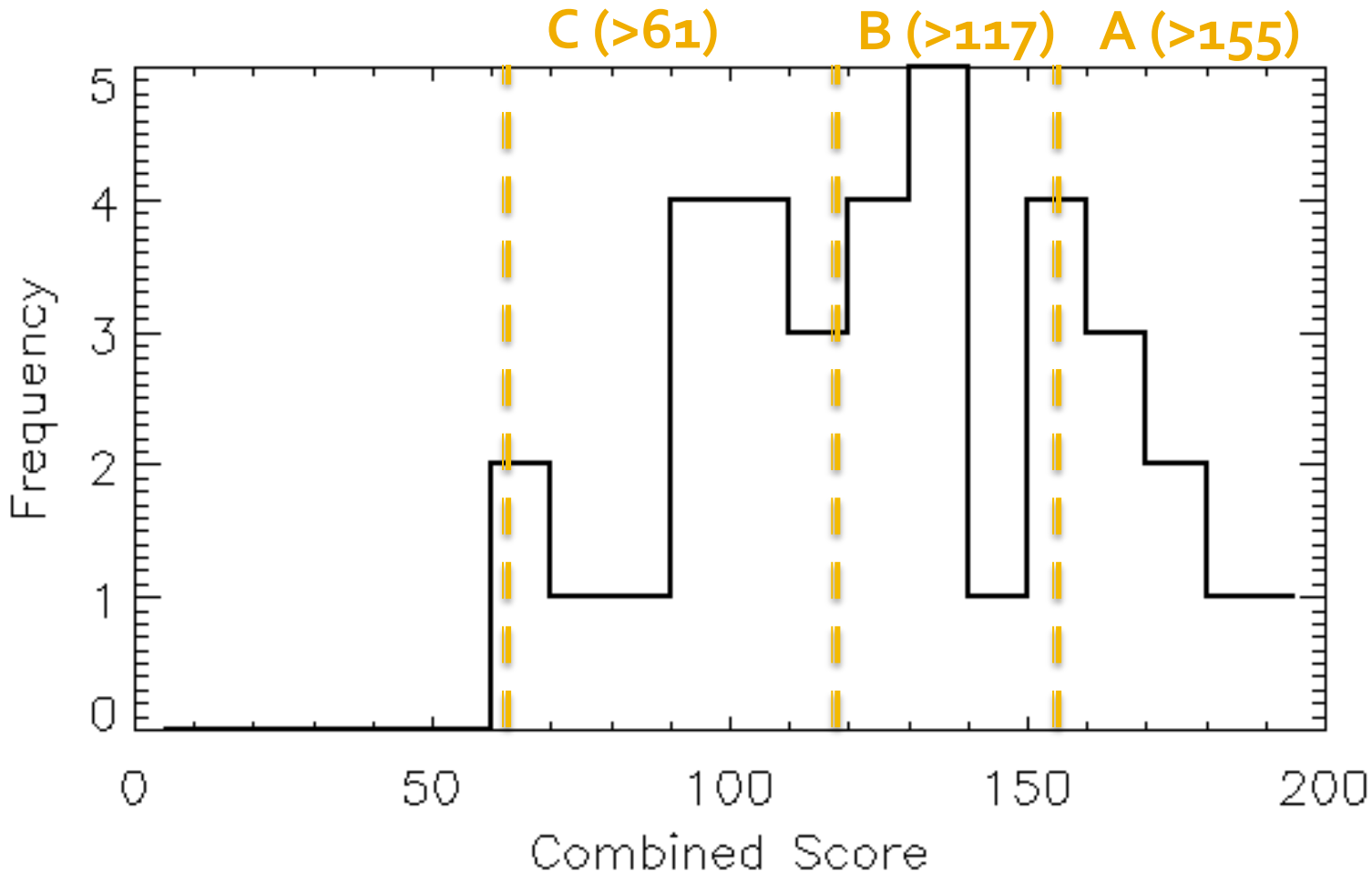
Midterm II Scores



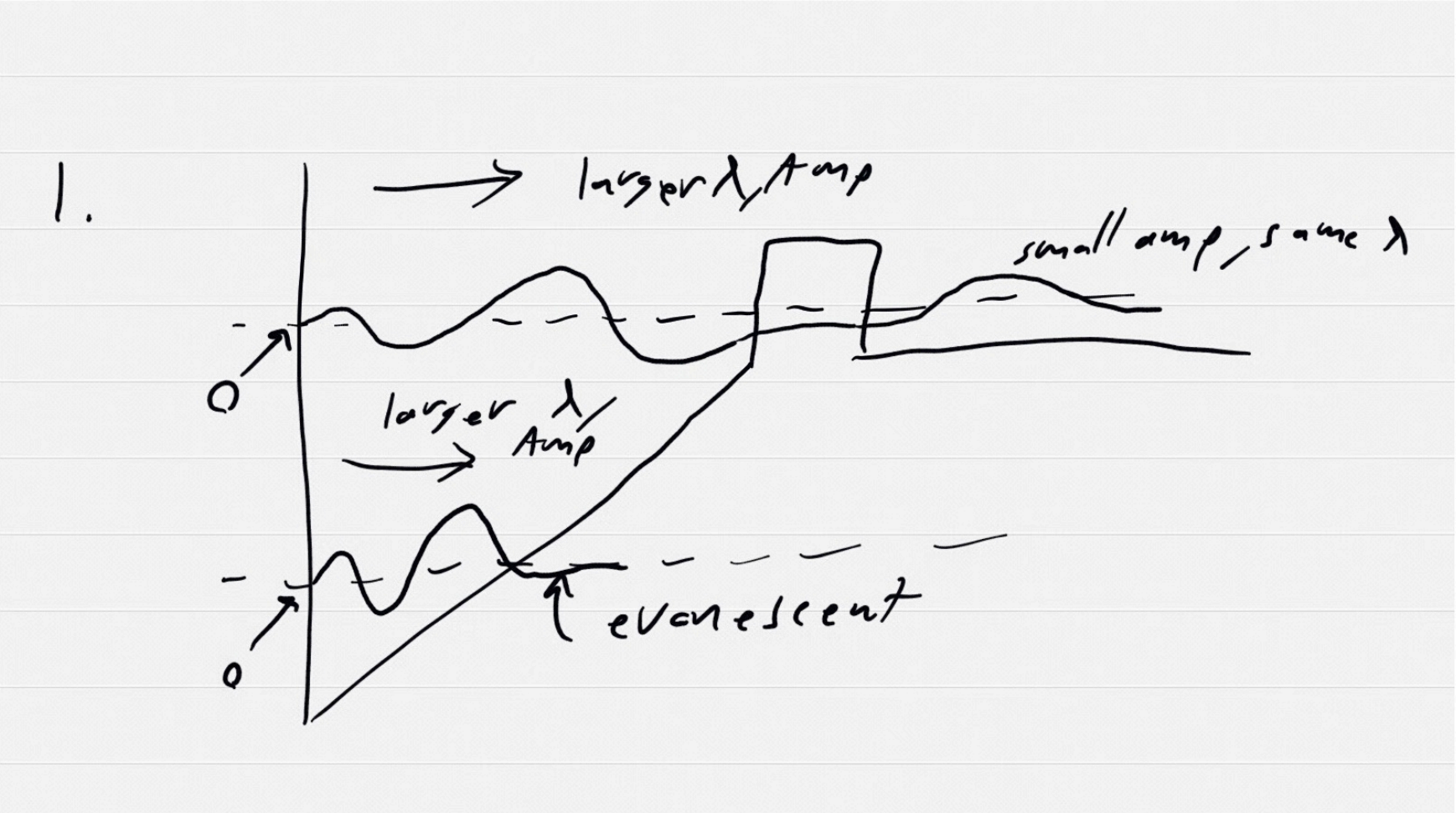
Combined Exam Scores



Very Approximate Grade Equivalents from CLAS Curve (Does Not Include Labs, HW, or Participation Extra Credit!!!)



Q1 Key Points



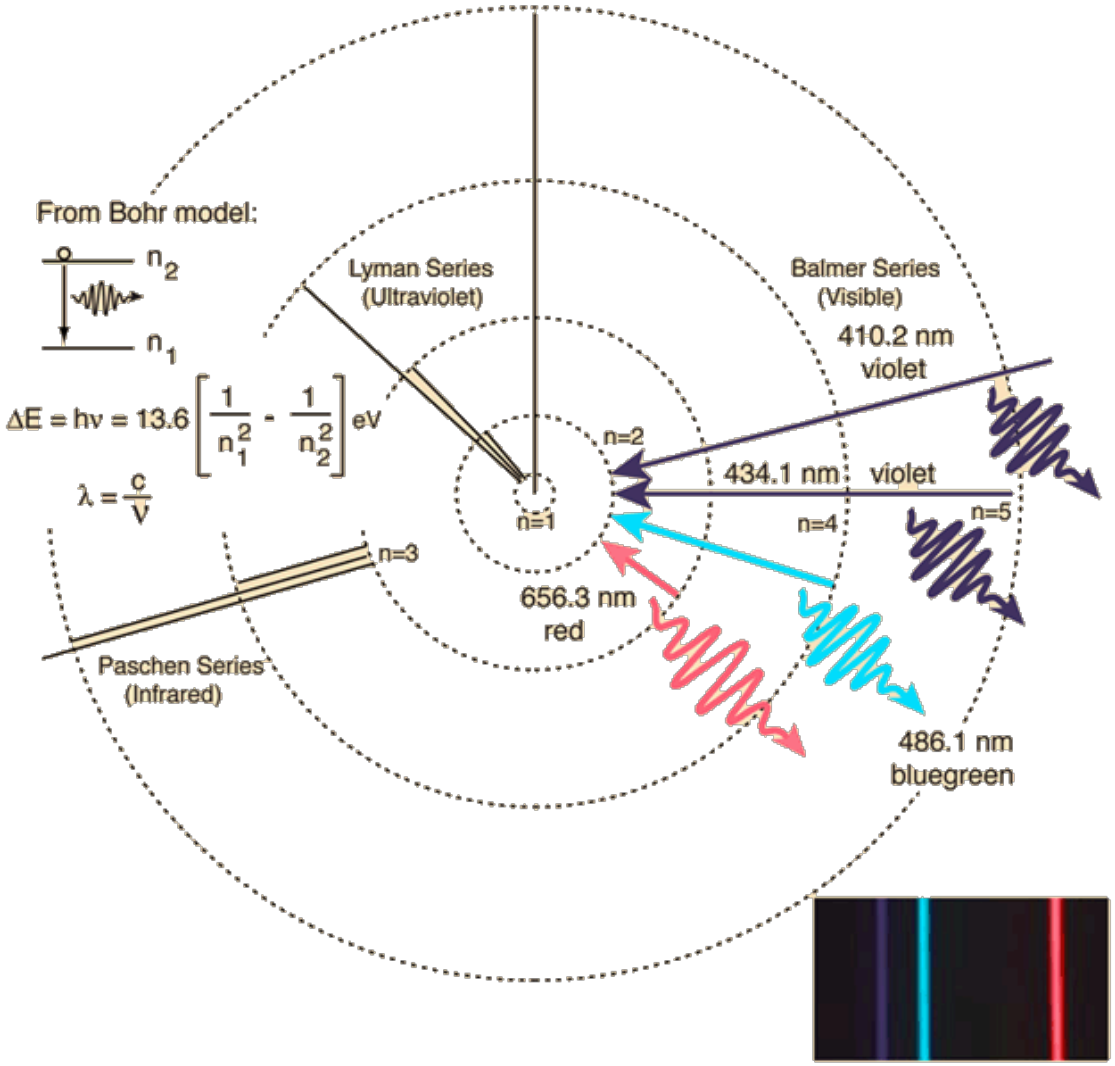
Q2 Key Points

$$\frac{-\hbar^2}{2m}\frac{d^2\Psi(x)}{dx^2}+U(x)\Psi(x)=E\Psi(x)$$

- Schrödinger equation must be satisfied for **all** values of x
  - All terms that don't depend on x must cancel, and all terms with a given power of x must cancel

Q3 Key Points

- Bohr energies proportional to Z^2/n^2
- Photon energies proportional to the **difference** in Bohr energies
- Longest wavelength <-> smallest energy change



Q4 Key Points

n = principal

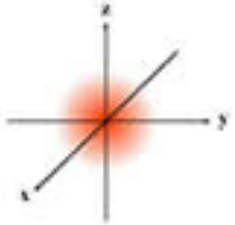
distance from nucleus

Energy

l = angular

shape of orbital

Orbital Angular Momentum



m = magnetic

orientation in space

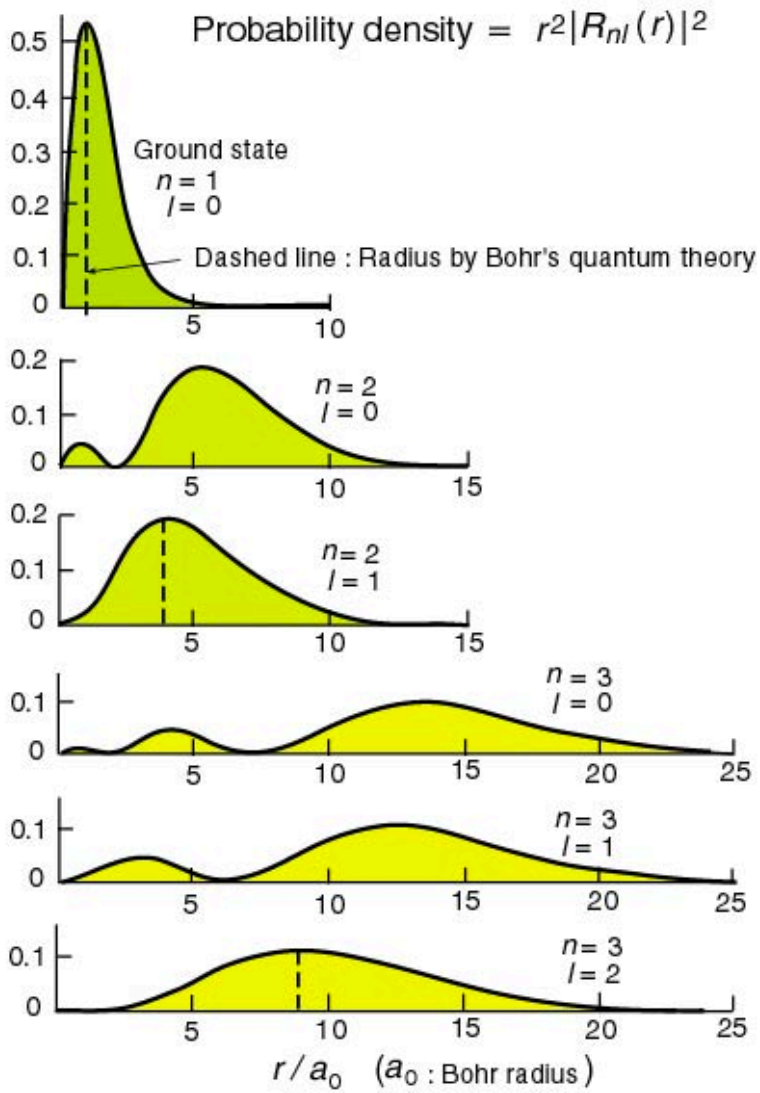
Direction of Orbital Angular Momentum

s = spin

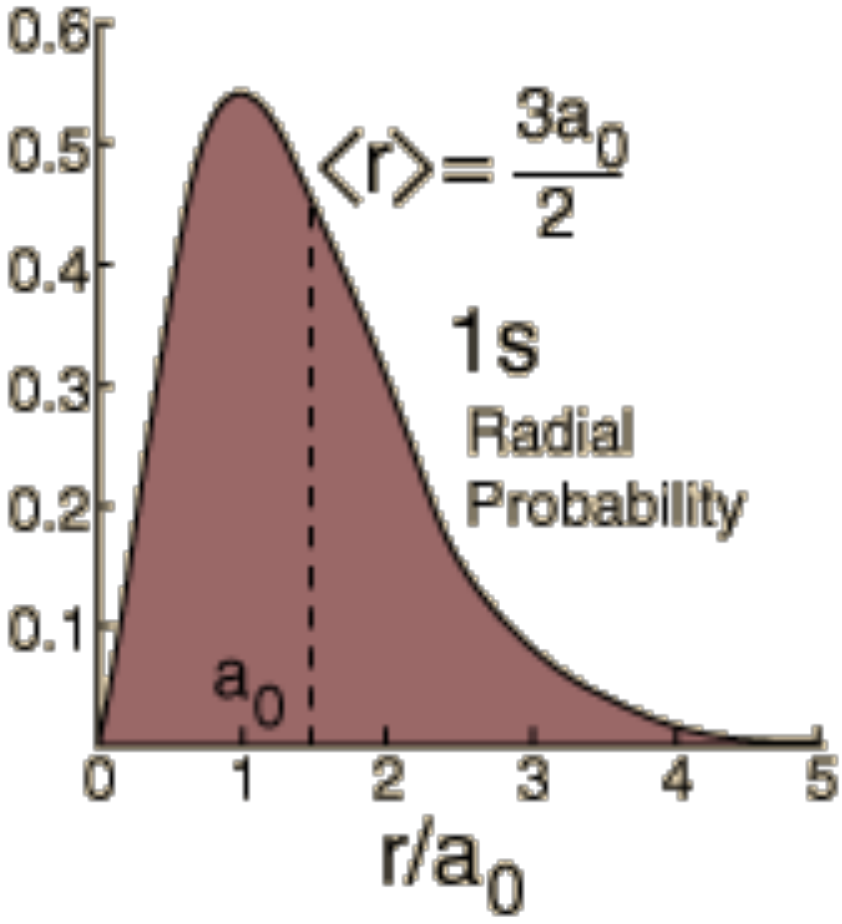
electron spin

Rotational Angular Momentum

Q5 Key Points



$$\langle r \rangle = \int_0^\infty rP(r)dr$$



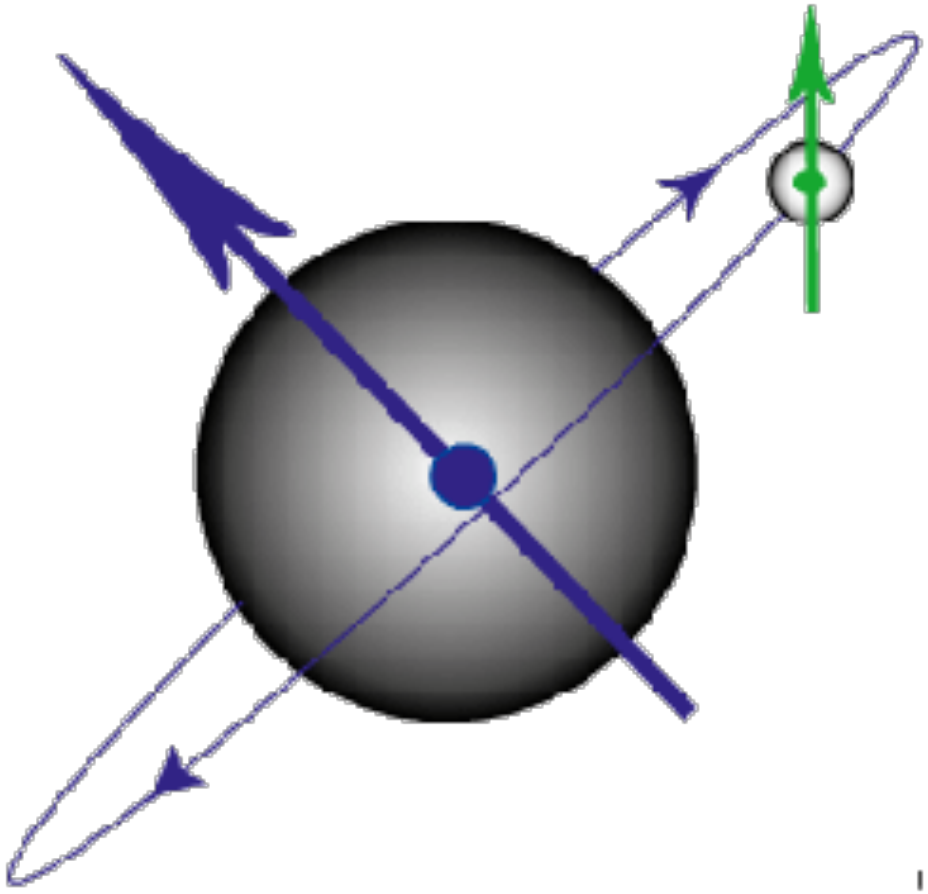
Q6 Key Points

$$\left|Y_{\frac{1}{2}}(\theta, \phi)\right|^2$$

- All angular probability densities are constant with azimuthal angle since $|e^{im\phi}| = 1$

- Direction of angular momentum is not the same as location of maximum probability!

Orbital and Spin Magnetic Moment



Orbital and Spin Magnetic Moment

$$\mu_B = \frac{e\hbar}{2m_e} = 9.2740154x10^{-24} J/T = 5.7883826x10^{-5} eV/T$$

Bohr magneton

Orbital $\quad \mu_L = -g_L \frac{e}{2m_e} L \qquad \mu_{Lz} = -g_L \frac{e\hbar}{2m_e} m_\ell = -m_\ell \mu_B$

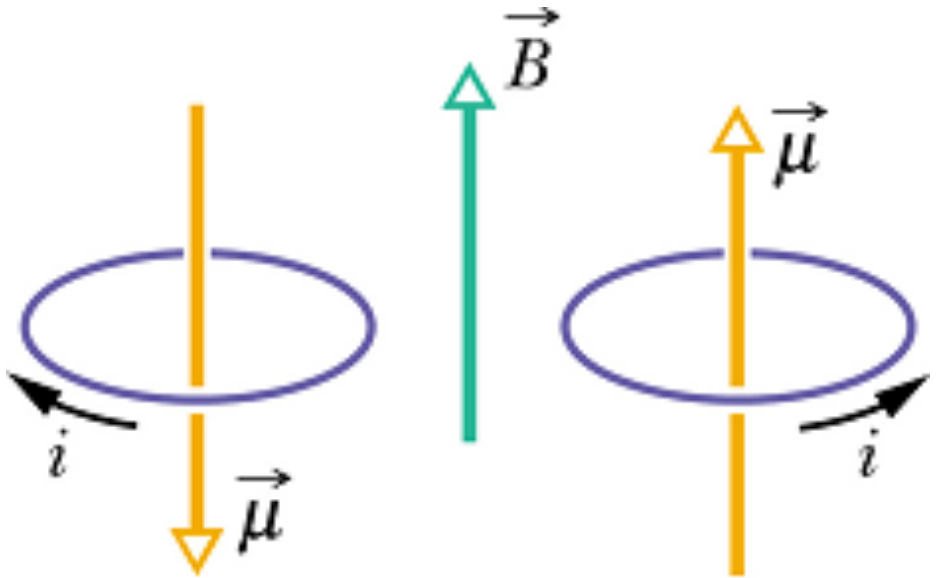
since $\quad g_L = 1$

Spin $\quad \mu_S = -g_S \frac{e}{2m_e} S \qquad \mu_{Sz} = -g_S \frac{e\hbar}{2m_e} m_s = -2m_s \mu_B = \pm \mu_B$

$g_S = 2.0023 \approx 2$

Magnetic Moment in Magnetic Field

$$U_{mag} = -\vec{\mu} \cdot \vec{B}$$



Highest energy

Lowest energy

Concept Check

- An electron is in the $n = 2, l = 1$ orbital. An external magnetic field is in the +Z direction. For which m_l is the electron energy lowest?

A. -1
B. 0
C. 1
D. All same

Concept Check

- An electron is in the $n = 2$, $l = 1$ orbital. An external magnetic field is in the +Z direction. For which m_l is the electron energy lowest?

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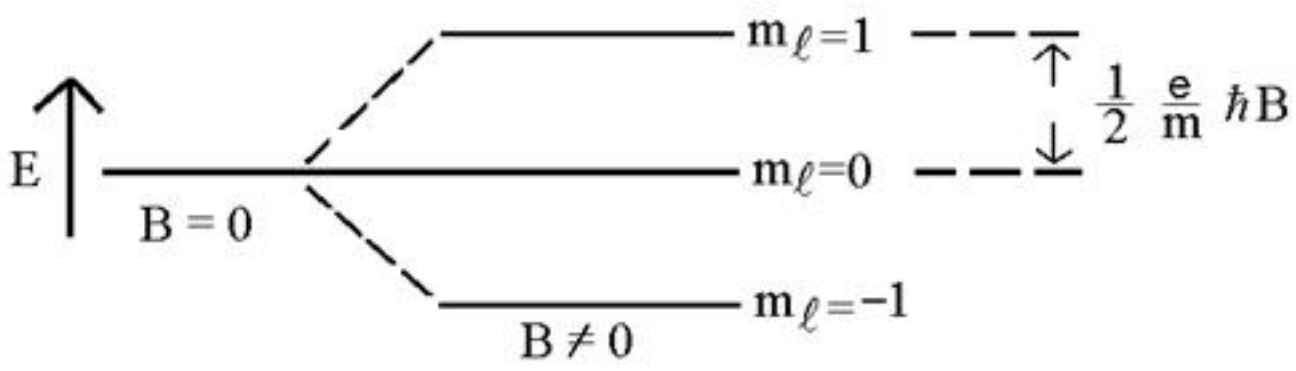
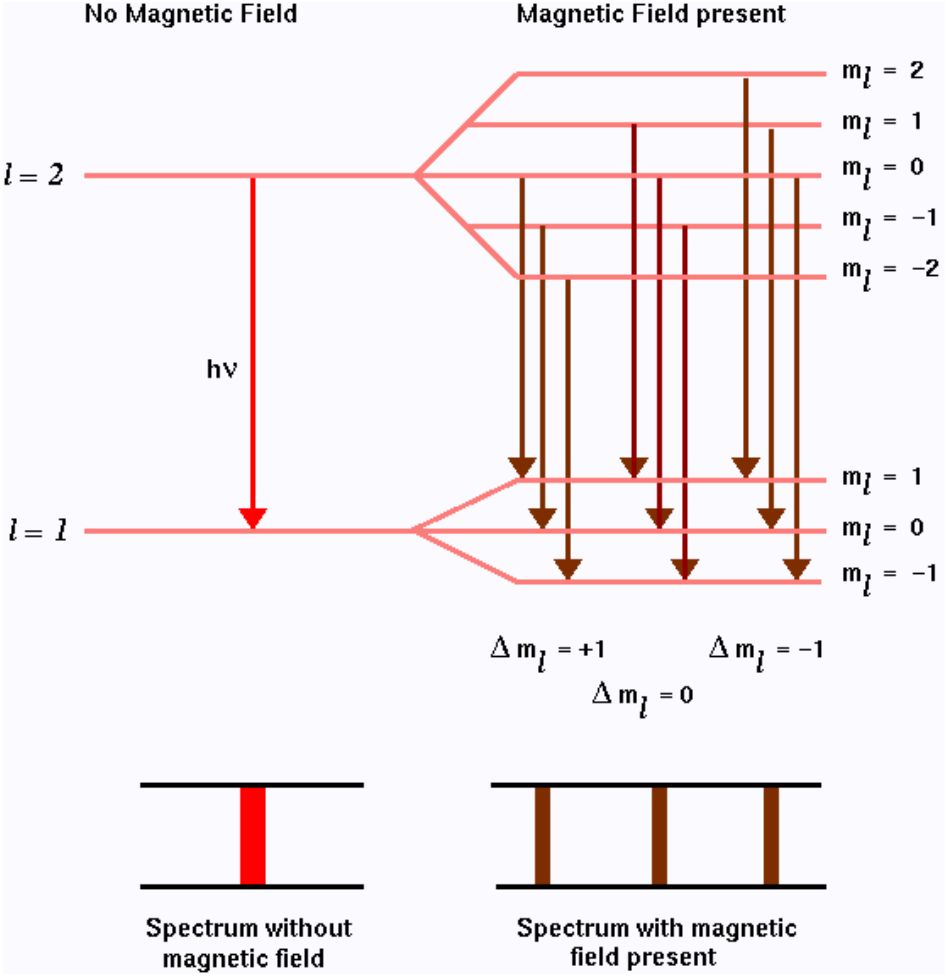


Zeeman Effect



Magnetogram

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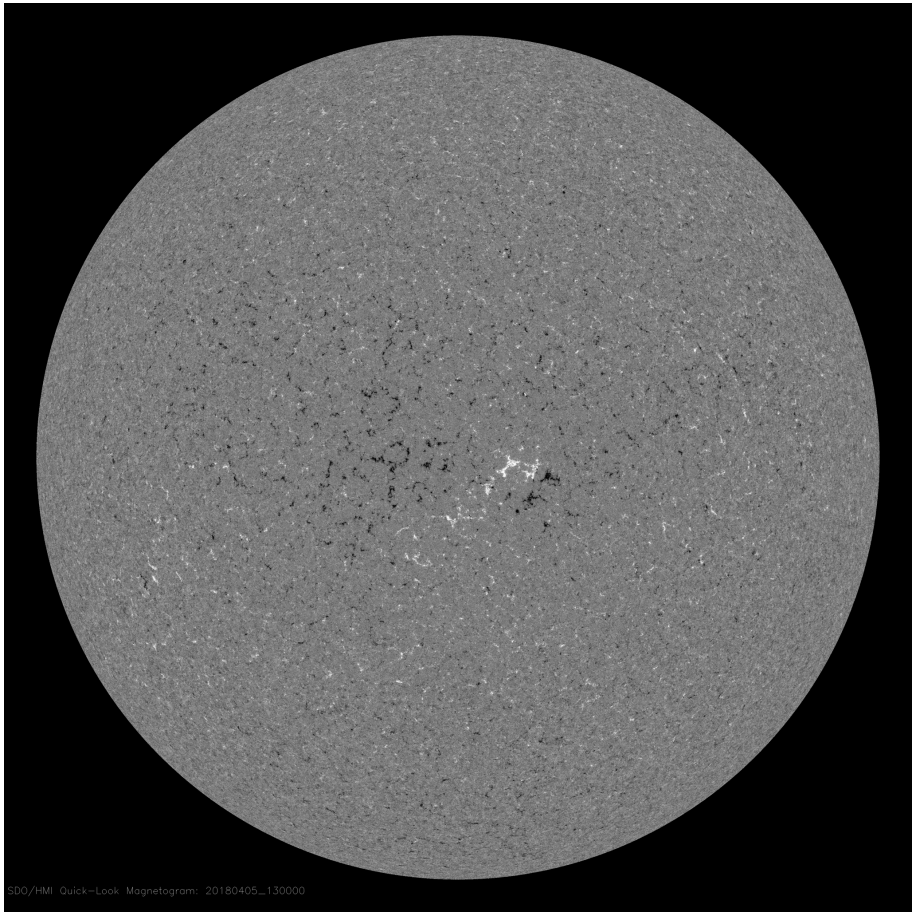

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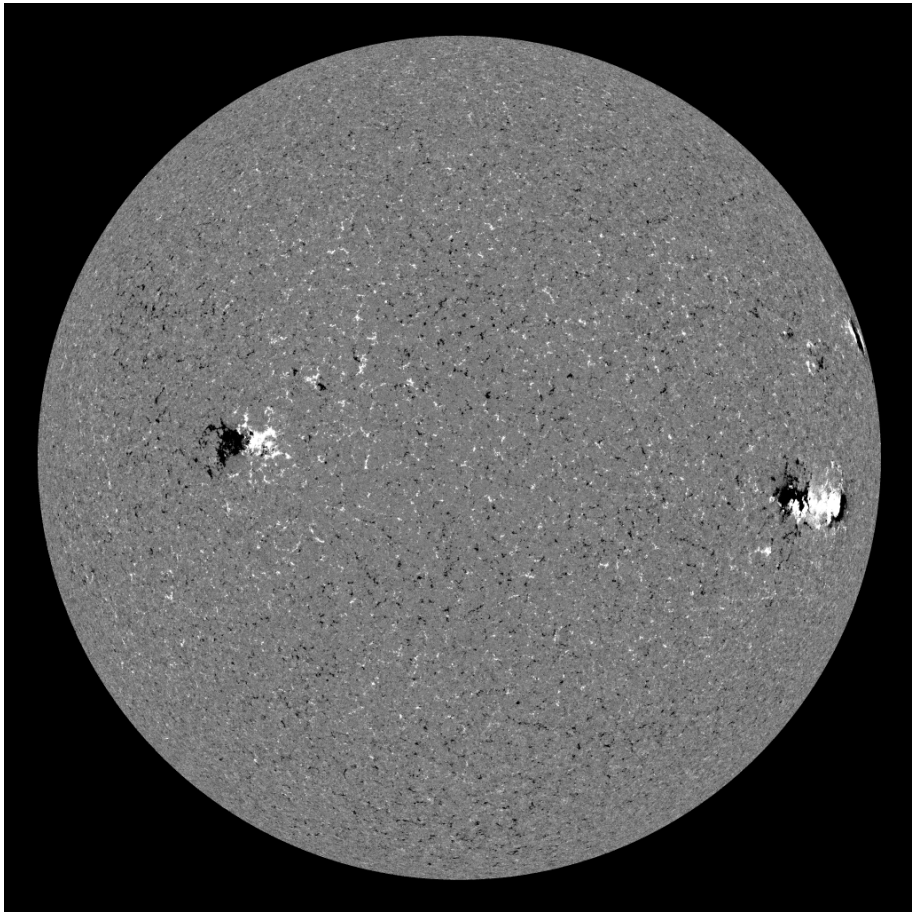
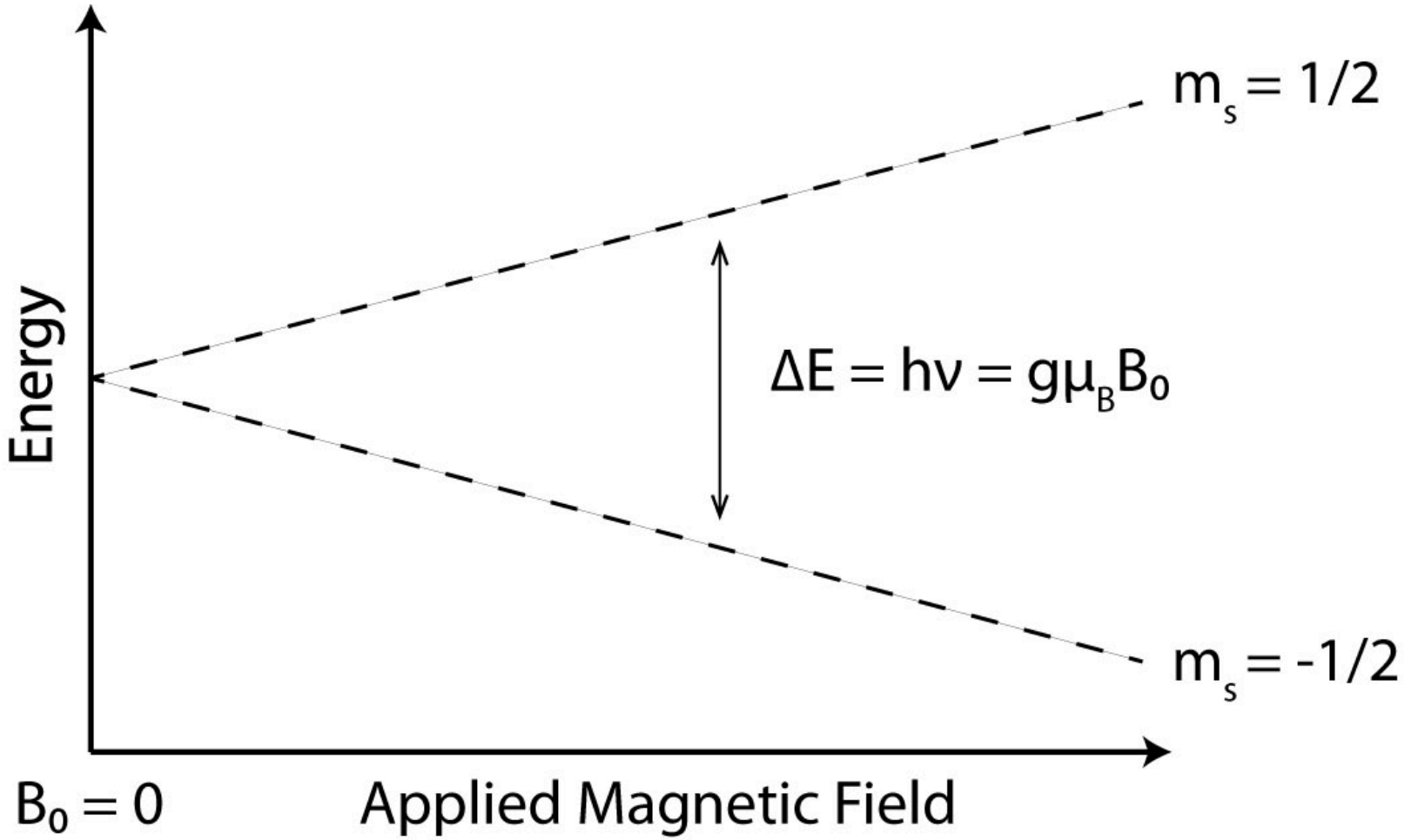
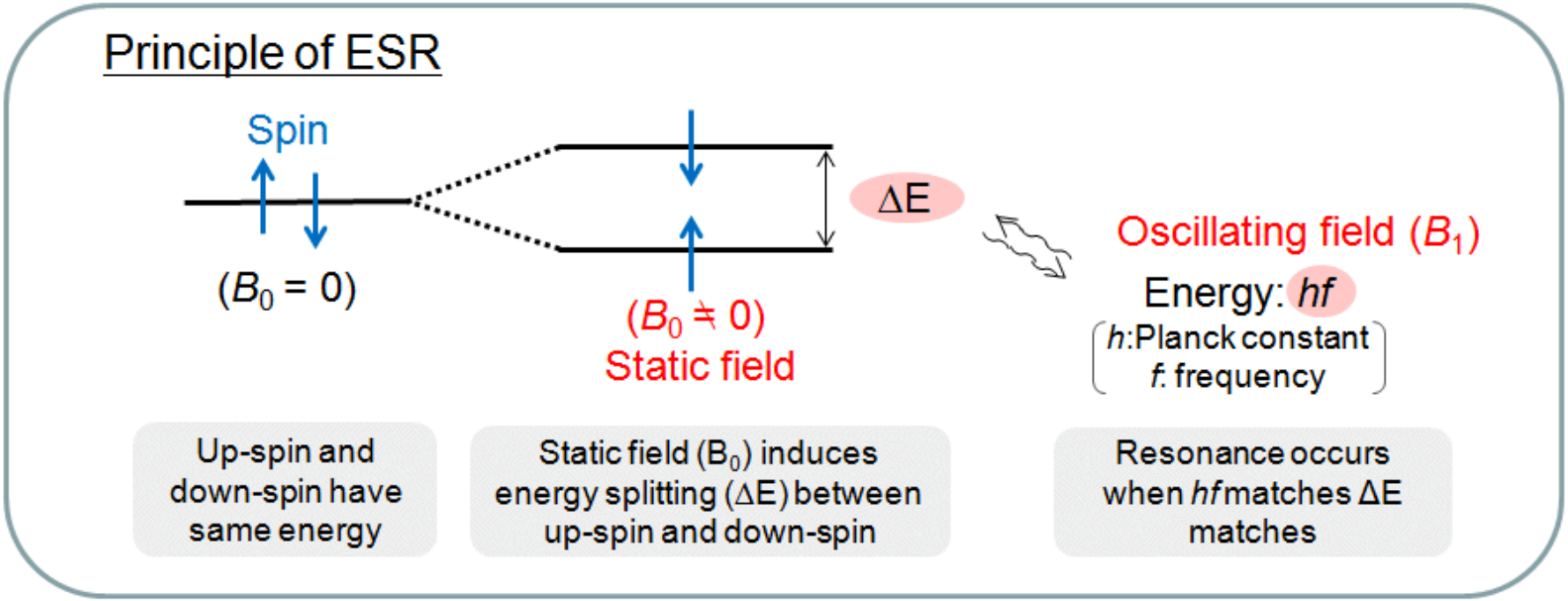


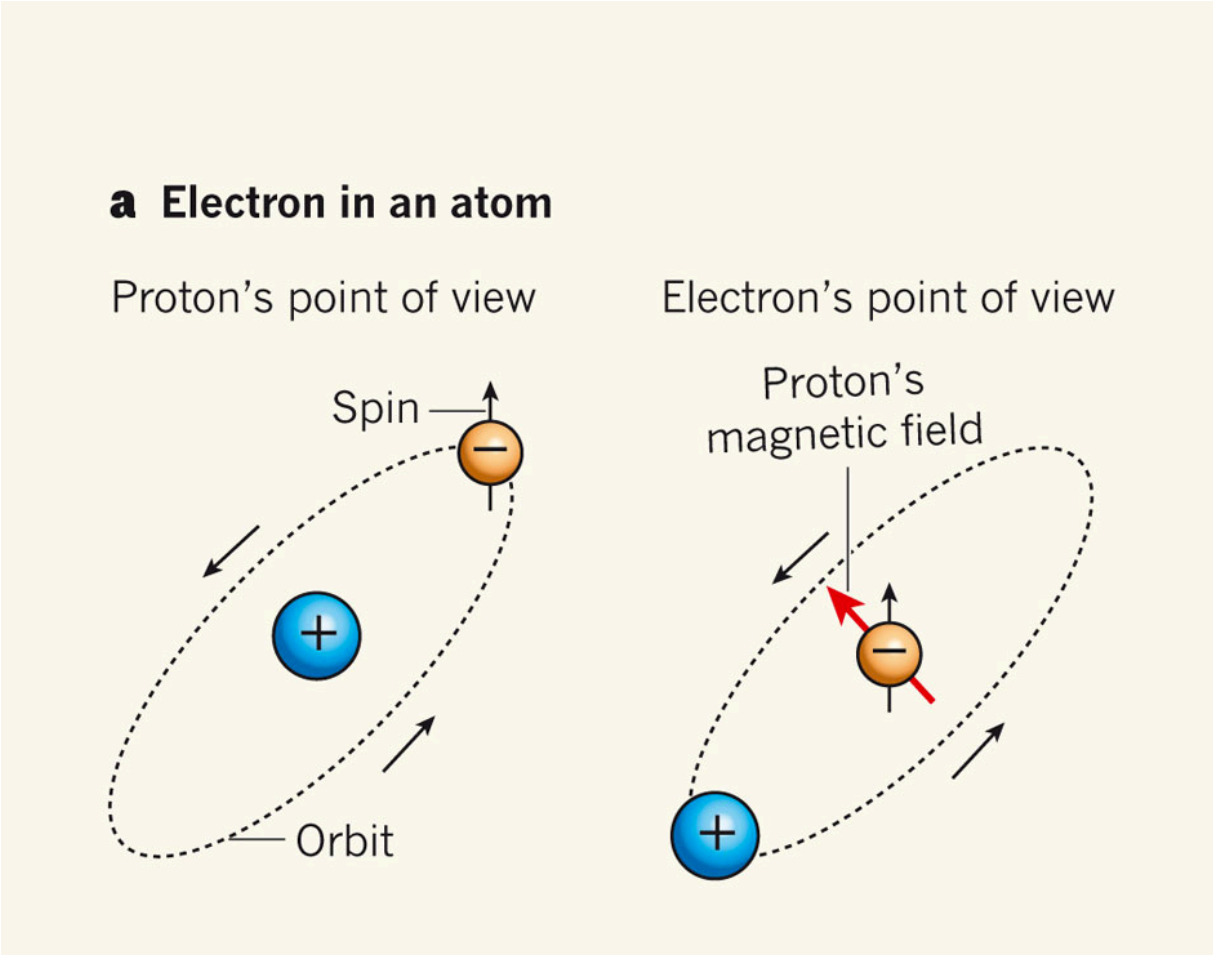
"Anomalous" Zeeman Effect



Electron Spin Resonance



Spin-Orbit Coupling

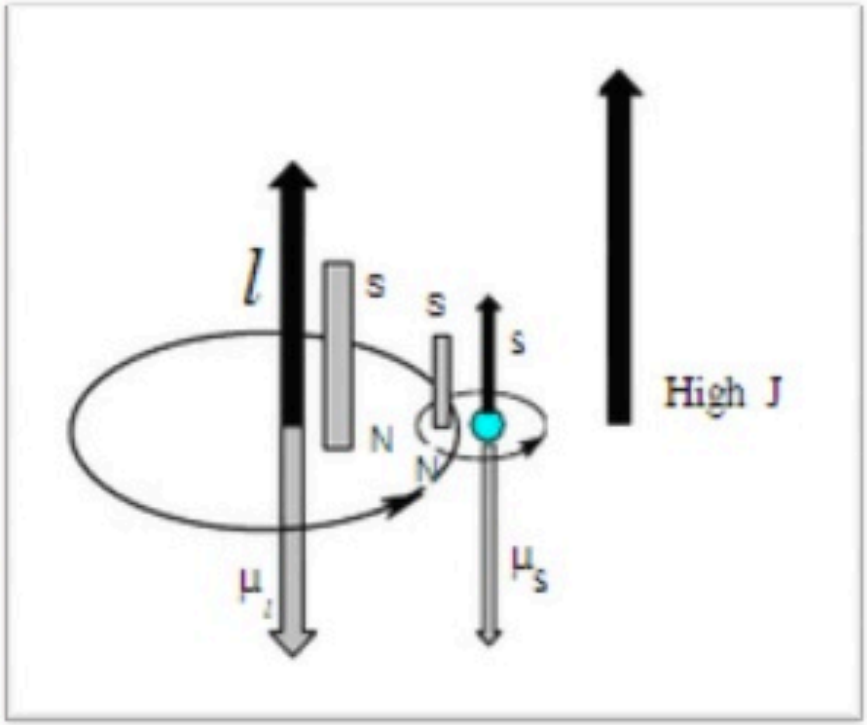


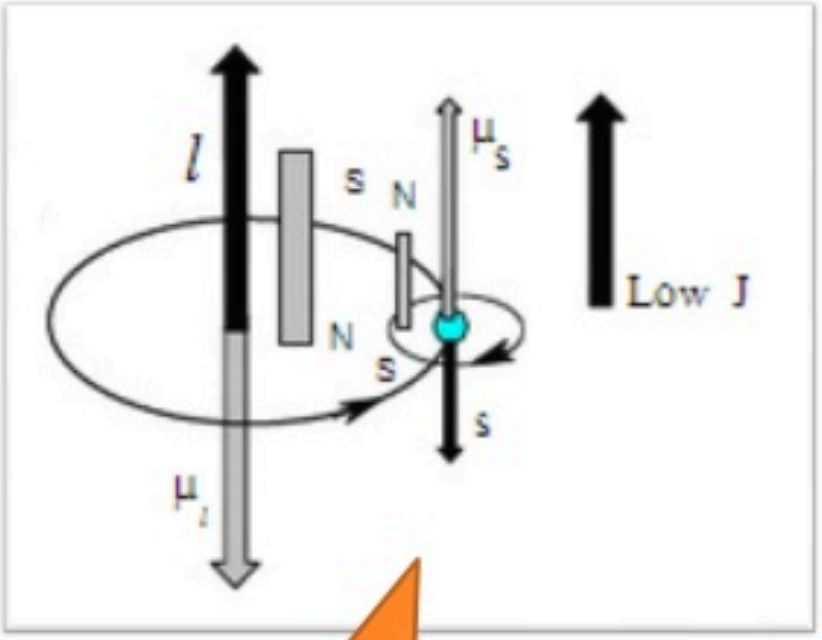
Electron orbit around proton causes field B in electron frame.

This leads to a shift in energy due to interaction of the electron spin magnetic moment with B.

Spin moment aligned (spin anti-aligned) with B has lower energy.

Spin-Orbit Coupling





Lower energy !

Spin-Orbit Level Splitting