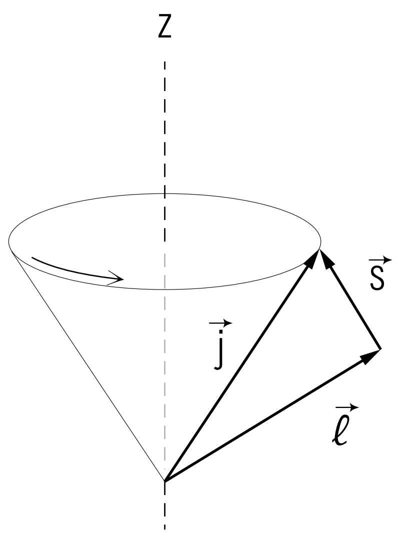
MISN-0-244

ELECTRON SPIN



Project PHYSNET Physics Bldg. Michigan State University East Lansing, MI

ELECTRON SPIN
by
Frank Zerilli

Title: **Electron Spin**

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Input Skills:

1. Vocabulary: angular momentum quantization, orbital angular momentum, Zeeman effect (MISN-0-251).
2. Add quantized angular momenta (MISN-0-251).
3. State the symbols used to denote the orbital angular momentum states of an atom (MISN-0-251).

Output Skills (Knowledge):

K1. Vocabulary: anomalous Zeeman effect, doublet, electron spin, fine structure, singlet, spin angular momentum, total angular momentum, spectroscopic notation, spin-orbit interaction.

K2. Describe electron spin in terms of the angular momentum of an extended object.

K3. Describe the physics of the spin-orbit interaction.

K4. Describe the Stern-Gerlach experiment and state its significance.

Output Skills (Problem Solving):

S1. Given the orbital and spin angular momentum for given atomic energy levels, label the levels with spectroscopic notation.

S2. Given the spectroscopic notation of an atomic energy level, find the orbital and spin angular momentum quantum numbers.

External Resources (Required):

1. Weidner and Sells, *Elementary Modern Physics*, 3rd Edition, Allyn and Bacon, (1980). See this module's *Local Guide* for availability.

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OF PROJECT PHYSNET

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Our publications are designed: (i) to be updated quickly in response to field tests and new scientific developments; (ii) to be used in both classroom and professional settings; (iii) to show the prerequisite dependencies existing among the various chunks of physics knowledge and skill, as a guide both to mental organization and to use of the materials; and (iv) to be adapted quickly to specific user needs ranging from single-skill instruction to complete custom textbooks.

New authors, reviewers and field testers are welcome.

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1. Assigned Readings

Read sections 7.6 - 7.8 in Weidner and Sells, *Elementary Modern Physics*, 3rd Ed., Allyn & Bacon (1980) (see this module's *Local Guide* for availability.

2. Notes on the Readings

- If an atomic system has only one valence electron, the electron spin quantum number has only one possible value, i.e. $s = 1/2$. With two or more valence electrons in the system, the total spin angular momentum is the vector sum of the individual spins, and the total spin quantum number can take other values (integer or half-integer).

- Just as in the case of adding orbital angular momenta, the total angular momentum quantum number j takes on values in integer steps between its maximum and minimum values, i.e.

  $$j = |\ell - s|, |\ell - s + 1|, \ldots, (\ell + s - 1), (\ell + s).$$

  Note that for $s = 1/2$ there is only one integer step between $j_{\rm max}$ and $j_{\rm min}$, but for $s \geq 1/2$, there is more than one integer step between $|\ell - s|$ and $(\ell + s)$. In the latter case there are more than two possible values for j.

LOCAL GUIDE

Reference: Copies of appropriate sections of Weidner and Sells, *Elementary Modern Physics*, 3rd Edition, Allyn and Bacon, (1980), are available at the reserve desk in the Physics-Astronomy Library: ask for "the readings for CBI Unit 244." Do not ask for the book itself.

PROBLEM SUPPLEMENT

1. What are the orbital, spin, and total angular momentum quantum numbers for the following states given in spectroscopic notation: $^2D_{5/2}$, $^2D_{3/2}$, $^2F_{7/2}$, $^1S_0$, $^3P_0$, ^3P, $^3P_2$, $^4I_{9/2}$.

2. List the possible states (in spectroscopic notation) which can result from the following combinations of orbital angular momentum ℓ and spin s;

   a. $\ell = 0$, $s = 1/2$

   b. $\ell = 1$, $s = 1/2$

   c. $\ell = 3$, $s = 3/2$.

Brief Answers:

1. $s = 1/2$, $\ell = 2$, $j = 5/2$; $s = 1/2$, $\ell = 2$, $j = 3/2$; $s = 1/2$, $\ell = 3$, $j = 7/2$; $s = 0$, $\ell = 0$, $j = 0$; $s = 1$, $\ell = 1$, $j = 0$; $s = 1$, $\ell = 1$, $j = 1$, $s = 1$, $\ell = 1$, $j = 2$; $s = 3/2$, $\ell = 6$, $j = 9/2$.

2. a. $^2S_{1/2}$

   b. $^2P_{1/2}$, $^2P_{3/2}$

   c. $^4F_{3/2}$, $^4F_{5/2}$, $^4F_{7/2}$, $^4F_{9/2}$

MODEL EXAM

1. See Output Skills K1-K4 in this module's *ID Sheet*. One or more of these skills, or none, may be on the actual exam.

2. List the possible states (in spectroscopic notation) that can result from the following combinations of orbital angular momentum ℓ and spin s:

   a. $\ell = 2$, $s = 0$

   b. $\ell = 2$, $s = 1$

   c. $\ell = 2$, $s = 1/2$

Brief Answers:

1. See this module's *text*.

2. a. $^1D_2$

   b. $^3D_1$, $^3D_2$, $^3D_3$

   c. $^2D_{3/2}$, $^2D_{5/2}$