SECTION 11

Atomic Spectra Fine and Hyperfine Structure

THE PROBLEM

In discussions of Quantum Mechanics a property of particles identified as "spin" and involving angular momentum occurs frequently. In those discussions it is often stated that no specific rotary motion (spin) is necessarily involved but that rather some intrinsic property of the particle being treated, an electron or an atomic particle, is what is intended. Yet the calling upon angular momentum quantized into two alternative states ('spin' up or 'spin' down) is part of those presentations.

The Stern–Gerlach experiment [see Section 13, below] appeared to demonstrate that the spatial orientation of angular momentum is quantized, and thus was an atomic-scale system having intrinsically quantum properties. This experiment was decisive in (wrongly) convincing physicists of the reality of angular-momentum quantization in all atomic-scale systems as for example the stable electron orbits in atoms [see Section 12].

That immediately raises the questions: What is it that makes the difference. (e.g. between 'spin' up versus 'spin' down).? Why are there just the two states not more ? What is going on with this quantization of angular momentum. ? What is its mechanism ?

The purpose of this section and the following two is to demonstrate that quantized angular momentum is not a "natural property of particles" and that the three behaviors contending that it is

- *atomic spectra fine and hyperfine structure;*
- *atomic electron specific stable versus unstable orbits;*
- *the Stern-Gerlach experiment.*

are completely explained by classical mechanics.

FINE STRUCTURE AND SPIN

When the line spectrum of Hydrogen is obtained with a spectrometer of high resolving power it is found that the lines that appear as simple single lines at low resolving power are in fact pairs of lines. This phenomenon is referred to as the *fine structure*. The splitting of the (low resolution) single line into (high resolution) two lines is on the order of about 1 part in 10^4. Sommerfeld addressed this problem showing that if the orbital electrons had elliptical orbits, in which the electron velocity would be relatively slow far from the nucleus and faster than for the circular orbit case near the nucleus, the relativistic mass increase at the higher velocity provided a minute energy increase that was on the order of the correct amount to account for the line splitting. That is, the elliptical orbit's energy would be slightly greater than a circular orbit's energy.

Sommerfeld's model for how the fine structure arises, a model based upon the conceived direct motion and action of the electrons, was soon superseded by Quantum Mechanics, a model that sought not to directly represent electron motion but rather to express the electron behavior and its effects. However, in spite of the wide spread acceptance of Quantum Mechanics, the concept of elliptical electron orbits has been retained.

Quantum Mechanics overthrew the Bohr-Sommerfeld theory shortly after its development. In Quantum Mechanics the fine structure is attributed to the interaction of the magnetic field due to the electron's spin on its own axis with the magnetic field due to the electron's orbit around the nucleus. This is referred to as spin-orbit coupling. The two cases that are contended to account for the two lines close together in the Hydrogen spectrum are for the electron's spin angular momentum vector in the same direction as the orbital motion angular momentum vector or in the opposite direction.

In a sense the conception that traditional 20th Century physics had of the electron is of a powder of negatively charged minute specks compressed into a little ball. (One of their concerns was that of what holds the electron together; with all of that charge packed so closely why does it not explode ?) In that sense, the electron is conceived of as spinning on its axis. It is conceived that the consequent circular motion of the specks of charge that are rotating about the electron's spin axis constitute a small current and generate a small magnetic field.

Actually, traditional 20th Century physics did not know, and had no way of knowing, whether the electron spins or not and if so then how rapidly, how (in traditional 20th Century physic's terms) the charge is distributed throughout the electron and what the electron diameter is, and so forth, all data necessary to calculation of its spin magnetic field. The contention of electron spin and its associated magnetic field depends entirely on that the concept is used to explain a fine characteristic in atomic line spectra. The amount of spin and the amount of consequent magnetic field was taken to be that at the value that explained the spectral fine structure.

But, for *Spherical-Centers-of-Oscillation* there can be no such concept. A c*enter-of-oscillation* cannot spin because of the nature of its structure and function.

Fine structure is the result of each orbital electron's having one or the other of two possible slightly different energy states in its orbit. In traditional 20th Century physics the two energy states result from the electron spin angular momentum (and magnetic) vector being in the same or opposite direction relative to the orbital motion angular momentum (and magnetic) vector. Spin in fact not being the cause because there is no spin, there must be some other cause that produces the same effect.

THE EFFECT OF ABSOLUTE MOTION

There is such another cause. That other cause is *absolute motion*, the motion of the Earth relative to the universe-wide absolute prime frame of reference, the effects of which have been neglected until now in the treatment of the behavior of the atomic orbital electrons. As was developed in Section 7, contrary to Einstein, there is an absolute frame of reference, an "at rest" frame. When the *Spherical-Center-of-Oscillation*'s oscillation is perfectly spherically symmetric then the center's velocity is zero and it is completely at rest. That is the universe's absolute frame to which all motion and all other frames are relative.

There exists throughout the universe a background radiation which is the residual radiation from the immense energy of the "big bang", the start of the universe. This

radiation is, of course, relative to the absolute frame of reference. Measurements of Doppler frequency shift of this radiation due to the motion of the Earth relative to the absolute frame give an absolute velocity for the Earth of about $370\ ^{km}/_{sec}$. The direction of the Earth's motion as indicated by those measurements is off in the direction from Earth of the constellation Leo.

The speed of the Earth in its orbit around the Sun is only about $31\ ^{km}/_{sec}$ so most of Earth's absolute speed is due to its motion relative to its galaxy, the Milky Way, and the absolute motion of that galaxy through space. Generally speaking it is likely that most if not all of the universe has a comparable magnitude of absolute velocity directed radially outward from the location of the original "big bang". But, whether or not, this *absolute* velocity of our Earth and our entire planetary-solar-galactic system of about $3.70 \cdot 10^5\ ^{m}/_{sec} = 0.0012 \cdot c$ must be taken into account in considering the behavior of the orbital electrons.

The most important factor in the stability of an atomic orbital electron is that it must not radiate energy. That requires that it experience no changes in the shape of its *Propagated Outward Flow* pattern of propagation forward, rearward and sideward. And, that requires that its speed remain constant. But, the speed of an orbital electron has two components: its orbital speed relative to the nucleus and its absolute linear speed because it is part of our overall solar system and galaxy.

In order for the electron to avoid radiating, it is its net speed, the resultant of those two components, which must remain constant. The way in which those two components combine to produce a net electron speed at any moment depends upon the orientation of the electron's orbital plane relative to the absolute velocity component of the electron, its atom and its solar-galactic system. The effect is illustrated in Figure 11-1, below.

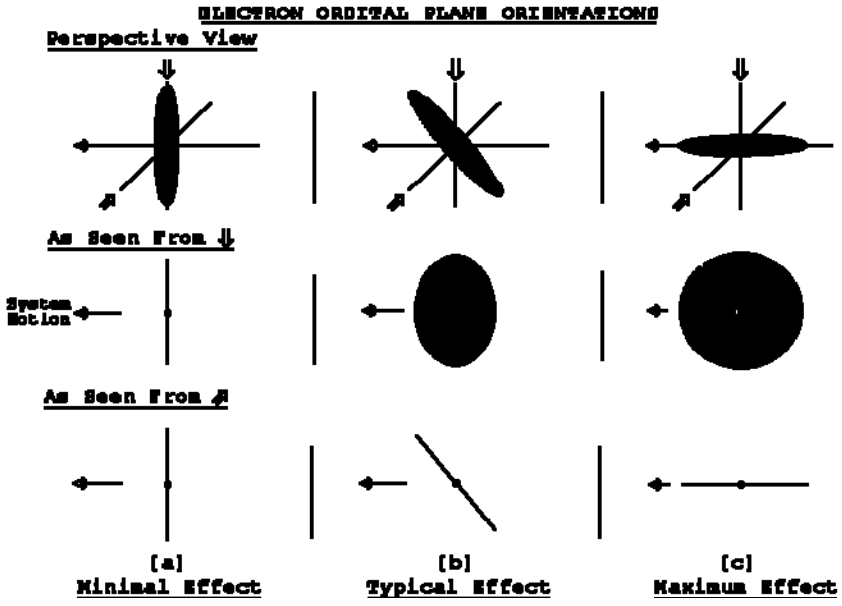

Figure 11-1
Relative Effect of Absolute Motion on Various Orbital Electrons

The figure illustrates different ways that the plane of an orbital electron's orbit can be oriented relative to the absolute motion of the overall atom. If the orbital plane is oriented at

right angles to the direction of absolute motion, as in the *[a] Minimal Effect* column of the figure, then the absolute motion produces the same change in the overall electron resultant speed everywhere in the orbit. The electron's total speed is that resultant. Its orbital speed relative to the nucleus is the circular orbit speed for that orbital shell.

On the other hand, if the orbital plane is oriented parallel to the direction of absolute motion, as in the *[c] Maximum Effect* column of the figure, then the overall resultant speed of the electron varies between the sum of its circular orbital speed and the absolute motion speed and the difference of the two speeds (see Figure 11-2, below). In general, orbital planes are frequently oriented between those two extremes as illustrated in the *[b] Typical Effect* column Figure 11-1. For such cases the absolute motion can itself be resolved into two components: one at right angles to the particular orbital plan (Case *[a]*) and one parallel to it (Case *[c]*) and the resulting overall effect analyzed in terms of a combination of those two extreme cases.

Figure 11-2, below illustrates the analysis of the Case *[c] Maximum Effect* circumstances.

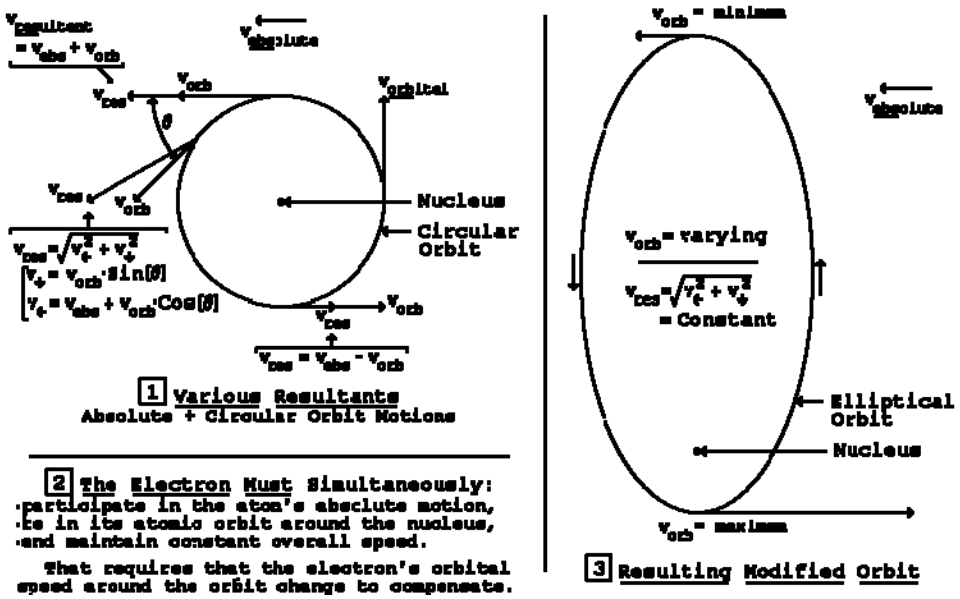

Figure 11-2

The figure is largely self-explanatory. If the electron is in a circular orbit (with consequent constant orbital speed) then the effect of the atom's absolute motion is to vary the electron's absolute speed, which is not acceptable. The only solution, the only *modus operandi*, is for the electron orbital speed to vary so as to compensate for the absolute motion and maintain constant absolute electron speed as shown in box 3 of the figure. The result is elliptical orbits for those orbits in which the orbital plane is not perpendicular to the direction of absolute system motion, that is for those orbits of Cases *[b]* or *[c]* of Figure 11-1.

The circular orbit speed in the $n = 1$ orbit of Hydrogen is about $2.2 \cdot 10^6$ m/sec. Our absolute speed is about $3.7 \cdot 10^5$ m/sec. The successive orbit speeds for $n = 2, 3, \ldots$ are $1/n$ times the $n = 1$ value. Thus the effect of absolute speed and the variations in orbital speeds are quite significant.

It is interesting to recall that the system of orbital quantum numbers developed by 20th Century physics and particularly elaborated by Dirac used the convention of the projection of an orbital angular momentum vector on a reference axis to define the various orbital tilts. It has now here been found that the "reference axis", an imaginary and missing element in traditional 20th Century physics terms, is actually the orbital plane orientation relative to the atom's absolute motion in space. The $\ell = 0$ value corresponds to the electron orbital plane being at right angles to the absolute motion, Case *[a]* of Figure 15-25. The $\ell = 1$ value produces a Case *[b]* situation. The horizontal orbit of Figure 11-2 is at right angles to the absolute motion and is circular. The other two orbits of the figure are now found to be elliptical, a pair tilted at equal but opposite angles relative to the absolute motion of the atom.

Returning to the problem of the cause of the *fine structure* in atomic spectra, there is a second consequence of the orbital electrons' absolute motion. Each electron has a component of magnetic field due to its straight line motion in space in addition to its orbital motion magnetic field. The electron's orbital magnetic field, which is perpendicular to the plane of the orbit, tends to align with the linear motion magnetic field that is due to the atom's absolute motion, which field is circumferential to the electron's direction of absolute motion. There are two possible alignment orientations, that is two orientations when there is no force acting that tends to change the orientation to one of the two. One is orbital motion in the same direction as the absolute motion magnetic field and the other is the opposite. The two differ slightly in energy. It is not "spin-orbit" coupling but "absolute motion - orbit" coupling that operates to produce the fine structure.

And that produces two “quantized” alternative values for the electron’s angular momentum.

And that does away with any electron ‘spin’ and any electron quantized angular momentum in this kind of case.

High resolution spectral techniques, including the use of tunable lasers, disclose an even more closely spaced splitting of spectral lines which is called *hyperfine structure*. Analogous to the quantum mechanical explanation of fine structure in terms of hypothesized orbital electron spin, the hyperfine structure is attributed to hypothesized nuclear spin, its consequent magnetic field, and its interaction with the electrons. But, the nucleus can no more have spin and a spin magnetic field than can an orbital electron.

The hyperfine structure stems from electron orbital magnetic field interaction with the magnetic field due to the nucleus' absolute motion in space. Of course, overall the nuclear and orbital electron absolute motion magnetic fields cancel out since the direction of absolute motion is the same but the polarity of the moving charges are opposite. However locally, within the atom there is not general cancellation.

Recognizing the affect of absolute motion on the atomic fine and hyperfine line spectra eliminates quantized angular momentum and electron “spin’’ as factors involved in those phenomena.

Next, the phenomenon of the atomic orbital electrons’ stable orbits.