Appendix A-3

Radioactivity

Radioactivity is an atomic nucleus spontaneously dividing into two (or more) lighter nuclei. Usually it consists of the emission of a relatively light particle and a resulting slightly reduced remaining nucleus. The relatively light particle emitted is usually an electron (- beta), positron (+ beta), helium nucleus (alpha), Hydrogen nucleus (proton), or a neutron. The process appears to be randomly spontaneous for the unstable nuclear specie and does not occur at all for the stable ones.

The reasons for nuclear stability / instability have already been discussed in the preceding section. Nuclei having sufficient mass / energy (*i.e*. having positive separation energy) to make up the decay product particles plus provide their escape energy are unstable. Those with negative separation energy experience stability enforced by the principle of conservation. However, the unstable nuclei do not promptly decay. If they did there would be none of them present now and they would most likely be completely unknown to us. The decay is a process extended in time in various amounts depending on the particular situation.

Characteristic of radioactive decay is that the rate of decay for a particular decay process of any particular nuclear specie continuously declines exponentially according to equation A-3-1.

(A-3-1) $$N = N_0 \cdot \varepsilon^{-t/\tau}$$

where: N = number of decays during time t.
N_0 = number of nuclei in the sample at time t = 0.
ε = the natural exponential base = 2.718282...
τ = (Greek letter "tau", a constant characteristic of the particular specie and its decay.

The form of this decay is depicted in Figure A-3-1 on the following page.

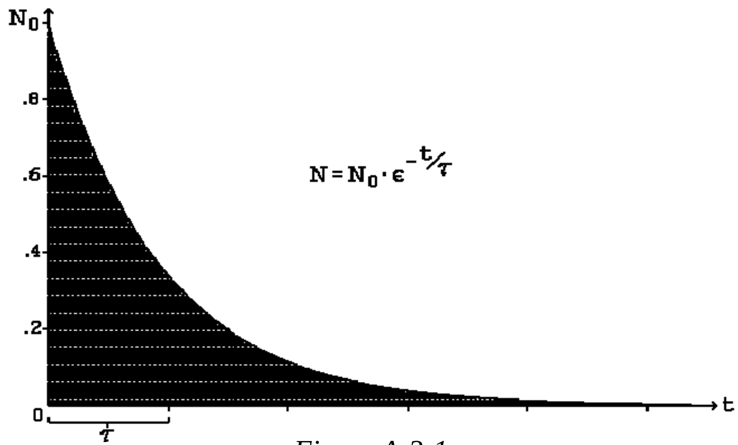

Figure A-3-1

This behavior comes about as follows.

Analysis of Radioactivity

As has already been presented, the wave forms of the various nuclear specie, *i.e.* the variation with time of the oscillation of their *Spherical-Centers-of-Oscillation* that are their atomic nuclei, are quite complex. In order for that nucleus to exist as it is at one instant of time and to exist an instant later as a different specie plus a second particle/ specie the transition must be smooth and continuous. And conservation must be maintained.

Those specifications place the following requirements on the oscillation wave forms throughout the transition.

(A-3-2) (1) The wave forms must be smooth:

$$U\left[{}_Z\text{Sym}^A\right]_{\text{Before}} = U\left[{}_Z\text{Sym}^A\right]_{\text{After}} + U\begin{bmatrix}\text{Emitted}\\ \text{Particle}\end{bmatrix}$$

(2) The rate of change of the wave forms must be smooth:

$$\frac{d}{dt}\left[U\left[{}_Z\text{Sym}^A\right]_{\text{Before}}\right] = \frac{d}{dt}\left[U\left[{}_Z\text{Sym}^A\right]_{\text{After}}\right] + \frac{d}{dt}\left[U\begin{bmatrix}\text{Emitted}\\ \text{Particle}\end{bmatrix}\right]$$

(3) The rate of change of the rate of change of the wave forms must be smooth:

$$\frac{d^2}{dt^2}\left[U\left[{}_Z\text{Sym}^A\right]_{\text{Before}}\right] = \frac{d^2}{dt^2}\left[U\left[{}_Z\text{Sym}^A\right]_{\text{After}}\right] + \frac{d^2}{dt^2}\left[U\begin{bmatrix}\text{Emitted}\\ \text{Particle}\end{bmatrix}\right]$$

(4) And so on for all successively higher rates-of change/ derivatives.

All of those specifications were applicable to the origin of the Big Bang treated in Section 1 and, as in that case, they require that the second, newly introduced particle, the "emitted particle" be of the *[1-Cos]* form as

(A-3-3) $$U[\text{Particle}] = U_c\left[1 - \text{Cos}[2\pi \cdot f_{\text{Particle}} \cdot t]\right]$$

The oscillation of the decaying nucleus is of the form

(A-3-4)
$$\begin{aligned} U\left[{}_{Z}Sym^{A}\right] &= A \text{ protons} + [N = A - Z] \text{ electrons} \\ &= U_c \cdot \left[A - Cos(2\pi \cdot [A \cdot f_p] \cdot t)\right] + \left[-U_c \cdot [N - Cos(2\pi \cdot [N \cdot f_e] \cdot t)]\right] \\ &= U_c \cdot \left[Z - Cos(2\pi \cdot A \cdot f_p \cdot t) + Cos(2\pi \cdot N \cdot f_e \cdot t)\right] \end{aligned}$$

and the above specifications also require simultaneously:

that the first instant of the new particle appear at a point in the overall oscillation of the radioactively decaying nucleus at which the ***N multiple electrons*** portion is at zero and just beginning a cycle of its oscillation;

and that the first instant of the new particle appear at a point in the overall oscillation of the radioactively decaying nucleus where the ***A multiple protons*** portion is at zero and just beginning a cycle of its oscillation.

Those requirements present a real problem because the specified *zero points* in each of the two different freqency's oscillations are rarely simultaneous and most likely never occur simultaneously. That is because both frequencies are always irrational numeric quantities and unable to relate as one being an integer multiple of the other. That is because both numeric values depend on the Planck Constant, h, which itself is irrational, equation *A-3-5*,

(A-3-5)
$$f = m \cdot c^2 / h$$

where m is the kinetic mass of the nuclear component multiple proton or electron.

While the oscillations' pairs of *zero points* do not achieve exact simultaneity they do approach it. The relative phase of the two oscillations, one at $A \cdot f_p$ and one at $N \cdot f_e$, is continually shifting and from time to time may become such that at some particular point the *zero points* are very close. Such closeness might occur every few seconds, or minutes or essentially regularly at longer intervals. At the lowest frequency / longest wavelength that could be involved, that of a single electron $f_e = 1.235,589,965 \cdot 10^{20}$ hz, there are that many electron *zero points* per second.

But, the oscillations of the various atoms of the element that is undergoing radioactive decay are not synchronized. They do not approach a pair of *zero points* at the same time. Rather their relative phases are distributed essentially uniformly over the range of relative points along the complex pattern of oscillation, equation *A-3-4*, at which they could be at any particular instant of time.

That is because unless they are at absolute zero temperature and energy all particles are in motion. Their oscillation pattern depends on their velocity, its speed and its direction. These particles regularly emit and absorb photons of radiation – the usual Rayleigh-Jeans or black body radiation activity. The particles' energies are continuously changed in consequence. That means that their velocities change and thus their oscillation patterns change.

A nucleus' *Separation Energy* includes energy in excess of that to account for the separated masses. So long as overall energy and momentum are conserved the requirements of equation *A-3-2* are somewhat flexible in the allocation of increments of the energy and momentum of the nucleus before decay partly to the remaining nuclear specie after the decay, partly to the emitted particle, and partly to an optional gamma, neutrino or whatever that may be radiated. Those energy increments correspond to minor variations in the particles' oscillation patterns, equation *A-3-5*. Thus the satisfaction of equation *A-3-2* can occur over a limited range of points that are in themselves very near to being a close pair of *zero points* in the oscillation pattern. An exact "match" to one single perfect *zero point* is not required because the variations in acceptable energies create some leeway.

There is a range of states, a "decay window", a small group of points along the total nuclear oscillation over its total period, within which the requirements of conservation and of equation *A-3-2* can all be satisfied. If the actual oscillation passes into any of the states within the "window" then the decay occurs.

At any instant of time a few individual nuclei are just a moment away from entering a state within a "decay window", some are within the "window", some are just leaving such a state. The vast majority are uniformly spread over the range of states between the "decay windows". If the average time between the beginnings of decay windows, the average duration before entry into a decay window, is referred to as τ then during a minute time interval Δt the fraction of the total number of nuclei in the sample that will progress in their oscillation pattern to the point of being in a decay window state is $\Delta t/\tau$. If there were no other factors affecting the process then the same fraction, $\Delta t/\tau$, would decay each Δt.

However, within that sample each nuclear *Spherical-Center-of-Oscillation* is continuously interacting with incoming *Propagated Outward Flow* of other centers and photons. The status of its oscillation is continuously being changed by those encounters and the consequent changes in energy and motion of the nucleus. For the purpose of determining where a particular nucleus is along its pattern of oscillation from one "decay window" to the next, each of the nuclei are continuously being shuffled and reshuffled, distributed and redistributed over the range of possibilities, effectively randomly, and effectively uniformly.

Thus the state of the above sample progresses as follows.

(1) Uniform distribution of states.

(2) In the next Δt fraction $\Delta t/\tau$ progresses in their oscillation pattern to the point of being in a decay window state and decays (It is a minute fraction since Δt is minute).

(3) The states of the undecayed fraction, $[1 - \Delta t/\tau]$ of the original total, are redistributed uniformly.

(4) Fraction $\Delta t/\tau$ of that undecayed remainder decays.

(5) The states of the undecayed fraction, $[1 - \Delta t/\tau]$ of the then undecayed remainder, again are redistributed uniformly,

(6) And so on.

This process yields an exponential decay as presented in equation *A-3-1* as follows.

(A-3-6) N ≡ the number of undecayed nuclei in the sample.
dN ≡ the change in the number of undecayed nuclei during infinitesimal time interval, dt.

$$\text{Number of Decays in dt as Fraction of } N = \frac{\Delta t}{\tau} \rightarrow \frac{dt}{\tau} \text{ as } \Delta t \rightarrow 0$$

$$dN = -N \cdot \frac{dt}{\tau}$$

$$\frac{dN}{N} = -\frac{1}{\tau} \cdot dt$$

$$\text{Ln}\,[N] = -\frac{1}{\tau} \cdot t + C$$

$$N = N_0 \cdot \varepsilon^{-t/\tau} \quad \text{which is equation A-3-1}$$

HOW THE RADIOACTIVE DECAY TAKES PLACE

A typical case is the radioactive decay of *Helium 6* into *Lithium 6* by the emission of a *-beta electron* and a *neutrino* [η] carrying off excess energy.

(A-3-7)

$$U\left[{}_2He^6\right] \Rightarrow U\left[{}_3Li^6\right] + U[\text{Electron}] + \eta$$

$$= U_c \cdot \left[2 - \text{Cos}(2\pi \cdot 6 \cdot f_p \cdot t) + \text{Cos}(2\pi \cdot 4 \cdot f_e \cdot t)\right]$$

$$\Rightarrow U_c \cdot \left[3 - \text{Cos}(2\pi \cdot 6 \cdot f_p \cdot t) + \text{Cos}(2\pi \cdot 3 \cdot f_e \cdot t)\right]$$

$$-U_c \cdot [1 - \text{Cos}(2\pi \cdot f_e \cdot t)] + \eta$$

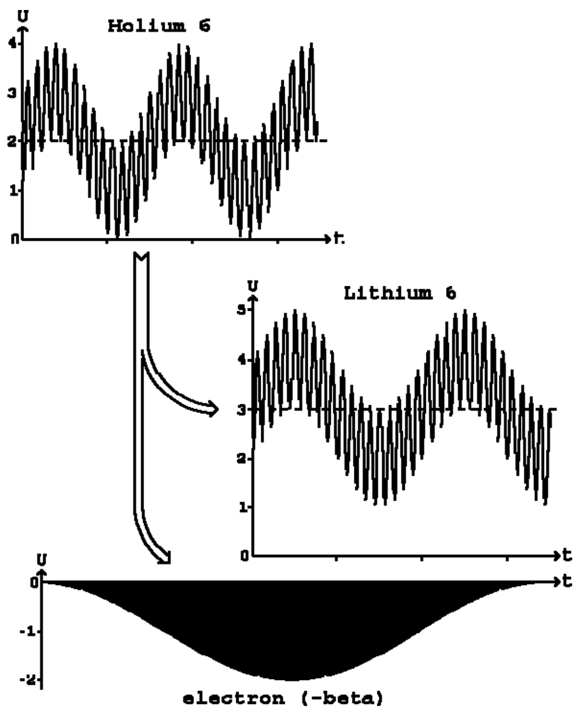

Figure A-3-2
Radioactive Decay of Helium 6 into Lithium 6 and an Electron

Initially from the above equation *A-3-7* and Figure A-3-2 it would appear difficult if not impossible to visualize or understand how the actual real world separation of the pre-decay nucleus into the decay products can take place. However, examining equation A-3-7 more closely it can be seen that the only change is in the multiple electron portion of the overall nuclear oscillation:

Before the decay the multiple electron portion of the overall oscillation is as follows. The change is the removal of one electron from the four.

(A-3-8)
$$-\left[4-\mathrm{Cos}(2\pi\cdot[4f_e]\cdot t)\right] \Rightarrow$$
$$-\left[-\left[1-\mathrm{Cos}(2\pi\cdot[1f_e]\cdot t)\right]\right] =$$
$$-\left[3-\mathrm{Cos}(2\pi\cdot[3f_e]\cdot t)\right]$$

The cosine function is the same as the following infinite series.

(A-3-9)
$$\mathrm{Cos}(x)=1-\frac{x^2}{2!}+\frac{x^4}{4!}-\frac{x^6}{6!}\;...$$

Expressing the multiple electron portion of equation *A-3-8* in terms of the cosine infinite series the result is equation *A-3-10*. [The factors 2π and t of each cosine argument are omitted for clarity, e.g. $2\pi\cdot[4\cdot f_e]\cdot t$ is rendered as $4f_e$.]

(A-3-10)
$$\left[4-\mathrm{Cos}(4f_e)=4-1+\frac{4f_e^{\;2}}{2!}-\frac{4f_e^{\;4}}{4!}+\frac{4f_e^{\;6}}{6!}...\right]\Rightarrow$$
$$-\left[1-\mathrm{Cos}(f_e)\;=1-1+\frac{f_e^{\;2}}{2!}-\frac{f_e^{\;4}}{4!}+\frac{f_e^{\;6}}{6!}...\right]=$$
$$\left[3-\mathrm{Cos}(3f_e)=3-1+\frac{3f_e^{\;2}}{2!}-\frac{3f_e^{\;4}}{4!}+\frac{3f_e^{\;6}}{6!}...\right]$$

[To avoid clutter e.g. $[4\cdot f_e]^2$ is done as $4f_e^2$]

There the process of particle separation and emission and the process of change in the remaining nucleus become clear.

Because the satisfaction of equation *A-3-2* can occur over a limited range of points that are in themselves very near to being a close pair of *zero points* in the oscillation pattern the failure of the decay to occur at an exact "match" to one single perfect pair of *zero points* accounts for the necessity of the neutrino product particle, the η of equation *A-3-7*.

THE NEUTRINO

- Neutrinos have been detected at energies of from 1 to 10^{17} eV, on the order of 10^{-9} to 10^{8} amu *equivalent*.
- They have no electric charge.
- They have an extremely small interaction with matter. That is, a neutrino can pass through an immense amount of matter with no apparent interaction (e.g.

the vast majority of solar neutrinos that encounter planet Earth simply pass completely through the Earth with no interaction.)

- The neutrino appears to be a "particle" with an extremely small rest mass equal to about one ten-thousandth, 0.0001, of an electron rest mass [otherwise by far the smallest].
- The neutrino is produced by radioactive decays.
- The options as to the form of the neutrino are: (1) A new type of *Spherical-Center-of-Oscillation* or (2) a kind of electromagnetic modulation of a center's *Propagated Outward Flow* caused by the center's motion, i.e. a form of photon.

Photons are generated by orbit changes of atomic orbital electrons. The orbital electrons have angular momentum and that angular momentum changes when the orbit changes so that the photon emitted carries off the change in the angular momentum of the electron.

Neutrinos, on the other hand, are generated by radioactive decay of non-orbiting atomic nuclei that do not have the angular momentum that atomic orbital electrons have. Whatever momentum neutrinos carry away from a nuclear decay is linear momentum, not angular.

Photons ranging from radiant heat to gamma, γ. rays occur over the same entire range of energies as do neutrinos. There is no accommodation for neutrinos in the family of photons.

The neutrino, then, is a new type of *Spherical-Center-of-Oscillation* of extremely small rest mass / rest energy and zero average oscillation value [no electric charge], $\eta = Cos(2\pi \cdot f_\eta \cdot t)$. The f_η is the equation *A-3-5* equivalent of the kinetic mass m_η of the neutrino.

The detection of neutrinos is a matter of detecting changes that they produce in encountered orbiting electrons. But, because the neutrino lacks the angular momentum necessary to be delivered to an orbiting electron to cause it to change orbits the neutrino seldom produces such a change. Now and then, but rarely, the circumstances may allow a neutrino-caused electron orbit change. The circumstances would be a neutrino encountering an electron where the spatial relationship of the neutrino's linear momentum to the electron's orbit were such that the neutrino need supply only a linear momentum change to achieve the effect of an angular momentum change on the electron.

"Strange" Particles

With the development of increasingly greater energies available in particle accelerators physics researchers have discovered an increasing number of particles.

Acknowledging that the analogy is somewhat brutal, nevertheless that research in high energy physics is not unlike the study of the composition and fundamental parts of a limousine by hurling everything from roller skates to motorcycles at it with as much energy as possible and then analyzing the resulting pieces.

It is true that little alternative seems to be available for experimental procedures to study the atomic nucleus, but when the magnitude of the disruptive energy used to generate the pieces is considered taking the resulting "pieces" seriously as a key to the nature of matter makes limited sense. Furthermore, those "pieces" may not be so much fundamental "building blocks" of matter as the fragments into which *Spherical-Centers-of-Oscillation* naturally break under such energies, so to speak a reflection of the "fault lines" in the center’s oscillations.

Of all of the many particles discovered in high energy physics research:

- Those having rest mass are *Spherical-Centers-of-Oscillation* (pieces that are centers smashed out of existing centers);
- Those having charge have oscillations with a non-zero average level;
- Those having momentum have a non-spherically symmetrical oscillation, the "axis" about which the oscillation remains symmetrical pointing in the direction of the momentum;
- Those not having rest mass are brief fluctuations in the *Propagated Outward Flow* from *Spherical-Centers-of-Oscillation*.

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