Dear Friends:

As you know I am exploring the possibility that the compactified fifth dimension in Kaluza-Klein is an intrinsic spin dimension. I have previously written about this in relation to charged leptons with spin ½. Now, let's consider compactification as regards the spin-1 photon. I'd like to get your feedback as to whether the following makes sense.

In 5-D, the metric interval is:

$$\begin{aligned} d\mathrm{T}^2 \equiv g_{\mathrm{MN}} dx^{\mathrm{M}} dx^{\mathrm{N}} &= g_{\mu\nu} dx^{\mu} dx^{\nu} + g_{5\nu} dx^5 dx^{\nu} + g_{\mu 5} dx^{\mu} dx^5 + g_{55} dx^5 dx^5 \\ &= d\tau^2 + 2 g_{5\sigma} dx^5 dx^{\sigma} + g_{55} dx^5 dx^5 \end{aligned} . \tag{1.1}$$

and the first integral of the equation of motion is:

$$1 = g_{\mathrm{MN}} \frac{dx^{\mathrm{M}}}{d\mathrm{T}} \frac{dx^{\mathrm{N}}}{d\mathrm{T}} , \tag{1.2}$$

For a photon, $d\tau = 0$.

For fermions, $x^5 \equiv R\phi$, R is constant, and so $dx^5 \equiv R d\phi$, with the results shown in http://jayryablon.files.wordpress.com/2008/03/intrinsic-spin-and-the-fifth-dimension.pdf. The primary result emerges from:

$$m \frac{R d\phi}{d\tau} R = \pm \frac{2}{b\overline{\kappa} c} qR = \pm \frac{2c}{b\sqrt{16\pi G}} qR = \pm \frac{1}{b} \frac{\sqrt{\hbar c^3 \alpha}}{\sqrt{G}} R \equiv \pm \frac{1}{2} \hbar . \tag{1.3}$$

which is (5.1) in the above-linked paper, yielding (5.2) therein: $R = \frac{b}{2\sqrt{\alpha}} \sqrt{\frac{G\hbar}{c^3}} = \frac{b}{2\sqrt{\alpha}} L_P$.

For a photon, $d\tau = 0$, but by (1.1), $d\mathrm{T}^2 = 2 g_{5\sigma} dx^5 dx^{\sigma} + g_{55} dx^5 dx^5 \neq 0$ and so the first integral of the equation (1.2) of motion is now:

$$1 = 2 g_{5\sigma} \frac{dx^5}{d\mathrm{T}} \frac{dx^{\sigma}}{d\mathrm{T}} + g_{55} \frac{dx^5}{d\mathrm{T}} \frac{dx^5}{d\mathrm{T}} . \tag{1.4}$$

In other words, $dx^5 / d\tau = \infty$ is undefined for the photon, but $dx^5 / d\mathrm{T}$ can still be perfectly-well defined.

Here is where I would like your feedback: I am inclined to simply introduce the hypothesis that the usual frequency f of a single photon is to be given by:

$$f \equiv \frac{d\phi}{d\mathrm{T}} , \tag{1.5}$$

i.e., as the frequency with which the photon undergoes rotation through the compactified fifth dimension. At the same time, this rotation is manifest through the photon's intrinsic spin $s = 1\hbar$, and the photon's energy is given by Planck's $E = n\hbar f$ with $n = 1$ because we are considering just a single photon. Of course the photon is massless, $m = 0$, but we can still make use of E/c^2 in place of m when considering a semi-classical angular momentum $m \cdot v \cdot R$ through the compactified fifth dimension.

So, let's put this all together. From (1.5)

$$E = \hbar f \equiv \hbar \frac{d\phi}{d\mathrm{T}}, \tag{1.6}$$

Then, we perform the same semi-classical analysis as in the paper linked above. The photon's spin angular momentum angular momentum is now hypothesized to be $s = \frac{E}{c^2} \cdot v_{(5)} \cdot R = \hbar$, with $v_{(5)} = \frac{Rd\phi}{d\mathrm{T}}$, and with R being the photon's fifth-dimensional compactification radius and $v_{(5)}$ being its velocity through the fifth dimension. Thus, using (1.6) as $d\phi / d\mathrm{T} = E/\hbar$, we now write:

$$s = \frac{E}{c^2} \cdot v_{(5)} \cdot R = \frac{E}{c^2} \cdot \frac{Rd\phi}{d\mathrm{T}} \cdot R = \frac{E}{c^2} \cdot \frac{ER}{\hbar} \cdot R = \hbar\,. \tag{1.7}$$

Using the last two terms above, this reduces to:

$$R = \pm \frac{\hbar c}{E}\,. \tag{1.8}$$

If we put $E = \hbar f$ back into the above,

$$R = \pm \frac{\hbar c}{E} = \pm \frac{c}{f}, \tag{1.9}$$

or:

$$R \cdot f = \pm c, \tag{1.10}$$

In vacuo, the wavelength and frequency are related by $\lambda \cdot f = c$, though of course in a gravitational field, c itself may be altered. SO:

The lesson of (1.10) appears to be that *in vacuo*, the compactification radius R of the photon's intrinsic spin is equal to its ordinary spatial wavelength, i.e.,

$$R = \lambda\,. \tag{1.11}$$

Keep in mind, R and λ, physically, are two different things. R is the fifth dimensional compactification radius. λ is the wavelength in ordinary, three-dimensional space. (1.11) says that *in vacuo*, the magnitude of each is the same.

This actually makes some sense of the always-challenging wave-particle duality. The "compactification radius" of the photon is clearly a "particle" concept which localizes the dimensions of the photon and causes it to exhibit particle properties. Yet, wavelength λ is a central wave concept.

Putting (1.11) into words: The compactification radius R of the photon *particle*, is equal to the wavelength λ of the photon *wave*. "Particle" and "wave" both slip off the tongue together, without the usual straining to understand, or confessions that we don't or can't understand. It is, indeed, both a particle and a wave. It has a "wavelength," and it has a "radius." "Wave," and "particle." The more energetic the photon, the more compact the particle becomes. More energy, smaller compactification. Less energy, larger compactification. These are inversely related. This is just a restatement of the Heisenberg principle for a Gaussian distribution. Also, very natural, without conceptual straining.

Let's also go back to the semiclassical $v_{(5)} = \frac{Rd\phi}{d\mathrm{T}}$ to ascertain the photon's tangential velocity through the compactified fifth dimension. Using (1.11) above as well as our original (1.5), this means that:

$$v_{(5)} = \frac{Rd\phi}{d\mathrm{T}} = \frac{\lambda d\phi}{d\mathrm{T}} = \lambda \cdot f \ . \tag{1.12}$$

Since $\lambda \cdot f = c$, this means that *in vacuo*, the fifth-dimensional tangential velocity through the fifth dimensions is:

$$v_{(5)} = c \ . \tag{1.13}$$

Thus, the photon's motion through the fifth dimension, is also at the speed of light.

What is noteworthy in contrast to the results for fermions (matter), is that for a luminous photon, the compactification radius is not fixed, but varies with wavelength. Since wavelength is not fixed but varies in relation to relativistic motion, this means that the compactification radius of a given photon is not a fixed size, but is only specified relative to a frame of reference. It can be anywhere from huge for a low-energy light wave (or for almost-light-speed redshifting movement away from a light source), to Planck scale for a high-energy light wave (or for almost-light-speed movement blueshifting toward from a light source).

The above specify the baseline properties of photon compactification, *in vacuo*, without gravitational fields. For a complex situations with motion and gravitational fields and matter, etc., we simply work from (1.4) to tell us exactly what happens.

I don't know if I want to put this in my other paper linked above, or leave this be for now. It seems almost too simple to be true. Your thoughts please on this analysis.

Thanks,

Jay.