(inhouse REV) <u>VACUUM POLARIZABILITY TENSOR,</u> by Norman Albers, 5/23/12

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If one examines the nullspeeds obtained for three orthogonal spatial dimensions, as per the previous gravitation study, the result is three scalar quantities associated with the spatial unit vectors. We start with a null geodesic, characterized by *ds=0 :*

$$0 = g_{ab}\, dx^a\, dx^b \quad ,$$

then examine changes in each space coordinate separately. Unitizing the SOL, *'c'* is taken as 1, so in a general spherical case we examine, in radial propagation:

$$0 = g_{00}(dx^0)^2 + g_{0r}\, dx^0 dx^r + g_{r0}\, dx^r dx^0 + g_{rr}(dx^r)^2 \quad .$$

In the Schwarzschild metric solution, there are no cross-terms and it is simple to solve:

$$c_r^2 \equiv (dx^r / dx^0)^2 = g_{00}/g_{rr} \quad .$$

Also in this metric, both: $g_{(\theta\theta)} = g_{(\phi\phi)} = -1.$

Thus the two angular nullspeeds are the same, and for the $\hat{\theta}$ direction,

$$c_\theta^2 \equiv (r\, d\theta / dx^0)^2 = -g_{00} \quad .$$

We may say the two angular terms are here degenerate, since the ϕ term is the same as the θ term. This will not be the case in, say the Kerr metric, which we will come to. It has a cross-term of $dt\, d\phi$.

There are good arguments by H. Puthoff on why vacuum electric permittivity and magnetic permeability must change together, and I deduced the same necessity, or at least intuited it . Thus: $c^2 = 1/\epsilon_0 \mu_o$

and if we are to allow increased values of both, we may express this by writing:

$$c_i{}^2 = 1/\eta(\epsilon_I)^2 \quad .$$

We define this subscript: *I:* <1,2,3> The altered permittivity is called: ϵ_i , and the constant η reflects the usual EM characteristics, or: $\eta \equiv \mu_0/\epsilon_0$.

Light consists of transverse EM disturbance, so let us consider the link between vacuum nullspeed and implied polarizability. Here, in the famous words of Steve Albers (!!) we must put on our thinking caps. We begin again with the Schwarzschild model since it is

the simplest. We have an expression for radial nullspeed, in terms of the far Euclidean coords. Such photons involve EM oscillation in the transverse plane, and this implies a transverse polarizable population. From the symmetry of the issue (not to mention my electron model) we may expect the two possible polarizations in this plane to behave the same. This gets more complex as we examine, say, propagations in the $\hat{\phi}$ sense. The field equations do not seem to differentiate, but we in this model posit radial populations not as great as the transverse. This follows because radial propagations are slowed more than transverse. (Remember, one looks at the perpendicular dipole availability.) A photon moving equatorially near a BH has two possible plane polarizations, one with radial field oscillations and the other with transverse oscillation in $\hat{\theta}$. If our theory is correct, we expect the latter nullspeed to be slower, whereas the former with radial oscillations will be not so slowed.
It should be noted here that both radial and tangential nullspeeds tend to zero at the event horizon, but the radial term is the square of the tangential, and thus the above difference.

Let us express a more general case, and write for a null geodesic:

$$0 = g_{ab}\, dx^a\, dx^b \quad .$$

Considering changes in one spatial dimension <i> , our analyses in any direction yield:

$$0 = g_{00}(dx^0)^2 + g_{0i} dx^0 dx^i + g_{i0}\, dx^i\, dx^o + g_{ii}(dx^i)^2 \quad .$$

In a study on the Kerr mathematics I showed one can go forth and solve this quadratic when there are cross-terms. Since the metric tensor is symmetric we can solve:

$$0 = g_{00}(dx^0)^2 + 2g_{0i} dx^0\, dx^i + g_{ii}(dx^i)^2 \quad ,$$

for an expression of c_i . [See my paper on Kerr.] Right now, though, the task is to connect the nullspeeds to implied permittivity, and thus to an implied polarizability. The nullspeeds give us values for permittivity, and we appeal to the Clausius-Mosotti equation to connect this to vacuum polarizability, as in the first part of this study (earlier paper). As noted above, a nullspeed in direction dx^i implies dipole availability in the directions perpendicular. Thus it is useful to define yet another subscript which denotes the two transverse directions: $h = \langle 1,2,3 \rangle, h \neq i$.

This will allow us to express the two transverse polarization possibilities for EM radiation.

Our notation starts with c_i and we note possibly distinct terms, so if we identify one subscript with propagation direction, and another with polarization sense, we may create a rank-2 tensor for polarizability: R_{ih} .

As noted, *i* ranges over <1,2,3> and *h* ranges over the two directions different from *I*. From radial propagations we can notate two possibilities, $R_{(r\theta)}$ and $R_{(r\phi)}$. Now we must render this theory self-consistent by recognizing the dipole availability in any direction is what is taken as the prime physical constraint. Thus we demand that for different propagations, lightspeed is determined by the dipole population relevant to the polarization. Now we discuss only plane polarizations. Let us write a general tensor matrix:

$$R_{ih} = \begin{pmatrix} 0 & R_{\theta r} & R_{\phi r} \\ R_{r\theta} & 0 & R_{\phi\theta} \\ R_{r\phi} & R_{\theta\phi} & 0 \end{pmatrix} .$$

If our sense of the dipole availability is correct then elements in the same row should be the same, irrespective of propagation sense. Thus we are reduced to three elements. The degeneracy in the Schwarzschild case is the equality: $R_{r\theta} = R_{r\phi}$, and here this relates two rows as equals. Possibly then it might be useful to say our tensor is actually of rank-1, and can be written as a vector: $R_{ih} \rightarrow R_i$. Now the subscript refers to the orientation of the vacuum dipole availability being considered.

There should be strong difference in light emitted close to tangentially, from near the limb and the EH of a black hole., depending on the sense of its polarization, whether vertical, or flat to the sphere. Redshift should be stronger for the transverse polarization.