# Quantum particle, light clock or heavy beat box?

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**Abstract**. The motion of a massive, relativistic quantum particle is compared to the system of light bouncing in a cavity, a so-called light clock. A pulse of light bouncing between two parallel mirrors acts as a clock with its period imposed by the mirror separation. In case the light wave is resonant with this parallel-mirror cavity, it is shown that the light shows a spatial beat (an intra-cavity Moiré pattern) when observed from a different Lorentz frame. For a massless, single frequency cavity and for a single, confined photon, the period of this spatial beat equals the de Broglie wavelength $\lambda_B = h/\gamma m_i v$ exactly. Notably, the inertial rest mass $m_i = \hbar\omega_0/c^2$ must be completely assigned to the confined photon. This is readily explained if we look at an accelerated cavity, in which the light bouncing inside is subsequently red and blue shifted along the axis of acceleration [1,2]. The unbalance in radiation pressure on the cavity results in a net force which is proportional to both the acceleration and its energy content $E = m_i c^2$. Clearly, by putting light in a box we are lead to physics reminiscent of the quantum domain as pioneered by Louis de Broglie. Starting from the energy-momentum relation in special relativity, $E = \sqrt{E_0^2 + p^2c^2}$, and taking the energy and momentum quanta $E_0 = \hbar\omega_0 = m_0c^2$ and $\vec{p} = \hbar\vec{k}$, he recognized that the dispersion relation demands that the quantum wave associated with a particle of velocity $v$ has phase velocity $v_{ph} = \omega/k$, with $k = k_B = \gamma m_0 v/\hbar$ while the velocity of the particle $v = v_{gr} = d\omega/dk = c^2/v_{ph}$ equals the wave's group velocity. In this paper, we show that in the rest frame of the cavity there is a photon with wave vector $\vec{k}_C$, while in a boosted frame there appears a single extra wave vector $\vec{k}_B$ which is related not to a single wave, but to a set of wave frequencies, the phases of which are in harmony at all the three different velocities. First of all, $k_B v_{ph} = \omega = \gamma\omega_C$ which is the frequency of the quantum mechanical wave. Second, a frequency that we will call the de Broglie frequency $k_B c = \omega_B = \gamma\beta\omega_C$, $\beta = v/c$. Third, the beat frequency between the photon and the cavity clock: $k_B v = \omega_{beat} = \gamma\omega_C - \omega_C/\gamma = \beta^2\gamma\omega_C$. Then, there may be a fourth, a sum frequency of cavity clock and photon wave: $\omega_Z = \gamma\omega_C + \omega_C/\gamma$. At low particle velocity the frequency is $\omega_Z = 2\omega_C$ reminiscent of the Zitterbewegung of a spin-½ particle. On the one hand, the spatial or momentum components show linear behaviour, while on the other hand, the time, frequency or energy shows nonlinear behaviour. While the linear superposition (addition) of fields gives a spatial frequency beat, its time domain shows that there is also frequency mixing (multiplication) which must be due to some nonlinearity that should be assigned to the cavity. In case of the light clock, we have effectively eliminated the cavity by assuming that it is infinitely rigid and at the same time massless. In case of the quantum particle, presumably, the nonlinearity is related to the internal binding forces (Poincaré stresses). In this paper we show how the de Broglie wavelength of a light clock and quantum particle may have the same origin. This has consequences, on the one hand, for the role of the photon and the nature of the cavity, and on the other hand, for the nature of matter, its binding force and the vacuum. The aim is to find appropriate boundary conditions to describe elementary particles within a parametric, nonlinear theory of topological electromagnetism [2,3,4,5].

**References (**please find more references in the following references**)**
https://www.researchgate.net/profile/Martin_Van_der_Mark

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