Calculation of X-Ray Signals
from Károlyházy Hazy Space-Time

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Abstract

Károlyházy’s hazy space-time model, invented for breaking down macroscopic interferences, employs wave-like gravity disturbances. If so, then electric charges would radiate permanently. Here we discuss the observational consequences of the radiation. We find that such radiation is excluded by common experimental situations.
1. Introduction

In a series of papers [1-3], Károlyházy et al. discussed the idea that space-time haziness puts an eventual limit on quantum coherence of massive systems. The following fluctuation has been introduced for the metric tensor:

$$g_{00}(x, t) = 1 + \gamma(x, t)$$

with the Fourier expansion

$$\gamma(x, t) = \sum_{k} (c_{k}e^{i(kx-\omega t)} + c.c.),$$

where $\omega = ck$. For the other components of the metric tensor no definite suggestion was made; the knowledge of $g_{00}$ is usually sufficient to describe nonrelativistic dynamics of masses. For technical simplicity, we have set unity for the volume. The complex coefficients $\{c_{k}\}$ are independent random variables of zero mean. The stochastic averages of squared modules satisfy the following relations:

$$<|c_{k}|^2> = \begin{cases} \Lambda^{4/3}k^{-5/3}, & k < 2\pi/\lambda_{\text{cut}}; \\ 0, & \text{otherwise.} \end{cases}$$

where $\Lambda = \sqrt{G\hbar/c^3} \approx 10^{-33}\text{cm}$ denotes the Planck length and $\lambda_{\text{cut}}$ is the cutoff parameter originally set to $10^{-12} - 10^{-13}\text{cm}$ [1-3]. Without a cutoff length the theory would be divergent.

In Refs.[1-3], the nonrelativistic Schrödinger equation was considered on the random space-time (1). The effect of $\gamma$ perturbing the metric tensor component $g_{00}$ is equivalent to introducing the potential

$$V(x, t) = \frac{1}{2}Mc^2\tilde{\gamma}(x, t)$$

into the Schrödinger equation. The tilde stands for averaging over the particle’s volume. According to the proposal of Refs.[1-3], the wave function generally obeys the Schrödinger equation with the potential (4) but, from time to time, instantaneous reduction processes interrupt the ordinary dynamic evolution.
In the present paper we concentrate on the periods of dynamic evolution between instantaneous reductions. We are going to calculate the electromagnetic radiation which is due to the electric charge of the particles, performing forced oscillation influenced by the potential (4). We find that the radiation would be surprisingly intensive and may be moderate only if the cutoff parameter $\lambda_{\text{cut}}$ is critically high. This result may strengthen previous warnings [4,5] that Eqs.(1-3) considerably overestimate the conceivable fluctuations of the space-time metric. The effect calculated here seems to be direct and inevitable consequence of the Károlyházy model.

2. Dipole radiation of oscillating charged particles

In this paragraph we calculate the electromagnetic radiation of a particle of charge $e$, performing oscillations forced by the fluctuations of the hazy space-time (1).

We start from the dipole formula [6] for the radiation intensity:

$$I_\omega = \frac{4e^2}{3c^3} |\tilde{\mathbf{x}}_\omega|^2$$  \hspace{1cm} (5)

where $\tilde{\mathbf{x}}_\omega$ is the Fourier transform of the acceleration of the charged particle. The dipole approximation is safe when the radiating charged source is much smaller than the wavelength $\lambda$. In our considerations the sources are the electrons and nuclei hence Eq.(5) remains valid well above $\lambda \simeq 10^{-13} \text{cm}$. (For atomic matter the electron shell as well as the whole neutral structure has the extension $\sim 10^{-8} \text{cm}$. For greater wavelengths the system reacts as globally neutral.)

It is known [6] that the dipole radiation (5) can equally well be calculated from the classical acceleration of the particle so, for the present purpose we shall use the classical Newton equation of motion instead of the Schrödinger one:

$$\ddot{\mathbf{x}}(t) = -\frac{1}{M} \nabla V(\mathbf{x}(t), t) + \text{other forces.}$$  \hspace{1cm} (6)

To calculate Fourier components of both sides, we make the following simplifying assumptions: i) the amplitude of the forced oscillation is small compared to the
wavelength $\lambda$ of the driving field (4), verified later, ii) other forces influencing the particle, as compared to the gravitational driving force on RHS. of Eq.(6), are ignored. Then, from Eqs.(2),(4) and (6), one obtains:

$$\ddot{x}_\omega = \frac{I}{2} e^{-i\omega c k} e^{ikx}$$  \hspace{1cm} (7)

Substituting this result into Eq.(5) and taking the stochastic average according to Eq.(3) one gets

$$< I_\omega > = \frac{4e^2}{3c^3} \langle |\dot{x}_\omega|^2 \rangle = \frac{4e^2c}{3} \Lambda^{4/3} k^{1/3}.$$  \hspace{1cm} (8)

There will be no radiation below the wavelength $\lambda_{cut}$ of the spectrum of the driving force (4).

To calculate the spectral intensity of the radiation, invoke the well known rule:

$$\sum_k \rightarrow 4\pi \int d\lambda \lambda^{-4}.$$  \hspace{1cm} (9)

So from Eq.(8) we obtain the final expression for the spectral intensity of dipole radiation:

$$\langle \frac{dI}{d\lambda} \rangle = \begin{cases} \frac{16}{3} (2\pi)^{1/3} \pi e^2 c \Lambda^{4/3} \lambda^{-13/3}, & \lambda > \lambda_{cut}; \\ 0, & \text{otherwise}. \end{cases}$$  \hspace{1cm} (10)

Consequently, the total intensity can be estimated as follows:

$$< I > = \int_{\lambda_{cut}}^{\infty} d\lambda \approx e^2 c \Lambda^{4/3} \lambda_{cut}^{-10/3}$$  \hspace{1cm} (11)

where a constant number factor of order unity is ignored.

We owe to justify assumptions i) and ii). From Eq.(7) we obtain the Fourier transform of the particle’s elongation:

$$x_\omega = \frac{I}{2} e^{i\omega c k} e^{ikx}.$$  \hspace{1cm} (12)

By using the above expression together with Eq.(3), the range of the squared amplitude of the forced oscillation is:

$$\langle |\Delta x|^2 \rangle \equiv \sum_k \langle |x_\omega|^2 \rangle \approx \Lambda^{4/3} \lambda_{cut}^{2/3}.$$  \hspace{1cm} (13)
Trying with the only reasonable cutoff values $\lambda_{\text{cut}} = 10^{-5} - 10^{-13} cm$, the average oscillation amplitude will be about $10^{-24} - 10^{-26} cm$. This extremely small amplitude directly justifies our assumption i). As for ii), when the particle is not free, the forced oscillations, due to their extremely small amplitudes, will simply be superposed onto the nonrelativistic motion of particles. Up to this, extremely good, approximation, the dipole radiation of the forced oscillations will not be affected by binding (or other) interactions. If in Eq.(6) other forces act they will cause, e.g., thermal radiation which will be incoherently superposed by the radiation (10).

Consequently, the calculated radiation formula (10) itself can be extended to interacting or even bound charged particles. Usually they will radiate decoherently, each according to the Eq.(10), provided the wavelength $\lambda$ is much smaller than the separation of the charged particles. (An interesting exception is the radiation of nuclei bound in ideal crystals where the driving forces are strongly correlated even at wavelengths much smaller than the lattice constant.)

3. Discussion

For calculating the outcoming radiation, one has to multiply the intensity (11) with the density of charges present, and integrate up for the volume of the source. We count only the charges which are free or bound in a system bigger than $\lambda_{\text{cut}}$. First consider the range $10^{-13} cm \leq \lambda_{\text{cut}} \leq 10^{-8} cm$. Then all charged particles of the atomic and even condensed matter would contribute to radiation decoherently since the average separation of charges (electrons, nuclei) is bigger than $\lambda_{\text{cut}}$. According to Eq.(11), some $10^{23}$ charged particles of a mole (e.g. several grams) of any condensed matter would produce a radiation with an overall intensity $\sim 10^{10} \text{erg/s}$ if $\lambda_{\text{cut}} = 10^{-12} cm$ or, still a considerable value $\sim 1 \text{erg/s}$ if $\lambda_{\text{cut}} = 10^{-9} cm$. In the spectrum the shortwave end $\lambda \approx \lambda_{\text{cut}}$ would dominate, so this radiation would mean hard $\gamma$ or X-rays: $\sim 10^{15} \gamma$-photons if $\lambda_{\text{cut}} = 10^{-12} cm$ or $\sim 10^8$ Röntgen-photons if $\lambda_{\text{cut}} = 10^{-9} cm$, per each mole.
Such number of hard photons is a dangerous radiation from e.g. lead used for shielding against $\gamma$-ray radiation, which would have been discovered long ago. Therefore certainly

$$\lambda_{\text{cut}} > 10^{-8} \text{cm}.$$ 

A great number of charged particles separated at larger than the above distance can be most typically found in plasmas. Consider a gas at 1 atmosphere, heated up above 3000$K$. Then it is in ionized plasma state and the average charge separation is cca. $10^{-6} \text{cm}$. Then for $\lambda_{\text{cut}} \approx 10^{-6} \text{cm}$ from one mole (e.g. cca. $1/4m^3$) of hot gas the radiation would be $10^{-10} \text{erg/s}$, i.e. $\sim 10$ photons per seconds, each of energy $\sim 100 \text{eV}$. 

This intensity is low; however at 3000$K$ the peak of the plasma’s thermal radiation is in the near infrared, while the $100 \text{eV}$ photons are somewhere between UV and X-rays. Their calculated intensity is by some 100 (!) orders of magnitude higher than the intensity of the thermal photons of the same wavelength.

Such nonthermal hard UV radiation should have been picked up by detectors long ago, and it has not been. So

$$\lambda_{\text{cut}} > 10^{-6} \text{cm}.$$ 

From the very essence of the model of Károlyházy et al. [1-3] follows that the cutoff parameter $\lambda_{\text{cut}}$ should not be macroscopic, see, e.g., in Ref.[7], too. Hence the remaining range is, e.g., $10^{-6} \text{cm} < \lambda_{\text{cut}} < 10^{-5} \text{cm}$. Here it seems that the inevitable electromagnetic radiation would not necessarily result in trivially drastic effects. (Namely, for the plasma experiment, one mole of dilute plasma with $10^{-5} \text{cm}$ average separation of ions would occupy a container of cca. 250$m^3$ while the photon flux would be cca. one photon of 10 $\text{eV}$ in a minute.)

So the fact that drastic UV radiation from very familiar kinds of matter around us and in laboratories is generally not detected leaves for the cutoff length necessary in the Károlyházy model [1-3] a narrow range

$$10^{-6} \text{cm} < \lambda_{\text{cut}} < 10^{-5} \text{cm}$$
Unfortunately this range seems to be excluded by cosmological considerations listed in a previous paper [5] of ours.

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