Fission with a Difference

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Invoking a model of an elementary particle as a collection of ultrarelativistic transient particles, we show that it is possible to recover the energy of the particle by bombarding it with monochromatic high-energy radiation.

Introduction

We consider the possibility of using an alternative route to releasing fission energy. This is prompted by some recent developments by the team of scientists Cruz-Chu *et al* [1], which leads to the technological development of practically monochromatic radiation in the X-ray region.

Let us start from a relativistic point of view, and the Lorentz transformation,

$$x = \gamma(x' - vt)\,, \quad \gamma = (1 - v^2/c^2)^{-1/2}\,. \tag{1}$$

Indeed it is known that for a collection of relativistic particles, the various mass centres form a two-dimensional disc perpendicular to the angular momentum vector $\vec{L}$ and with radius [3]

$$r = \frac{L}{mc}\,. \tag{2}$$

Further if the system has positive energies, then it must have an extension greater than r, while at distances of the order of r, we begin to encounter negative energies.

If we consider the system to be a particle of spin or angular momentum $L = \hbar/2$, then (2) gives $r = \hbar/2mc$. That is, we are in the Compton wavelength region. Another interesting feature which is the two dimensionality of the disc of mass centres.

On the other hand it is known that (cf. [4]), if a Dirac particle is represented by a Gausssian packet, then we begin to encounter negative energies precisely at the same Compton wavelength as above. Thus a particle can indeed be treated as a spherical shell of relativistic transient sub-constituents or "particlets". Indeed, this is an alternative description of Dirac's zitterbewegung or rapid oscillation.

The above picture is also reminiscent of Dirac's shell or membrane model of the electron [5–7].

Outside this Compton region we have the usual space (or space time) of physics. But as we approach the Compton wavelength region we encounter a region where the space axis becomes as it were a complex plane. This has been described at length by the author, in terms of the Feschbach formalism [8] which leads to the double Weiner process. Consider the following system [9]

$$\begin{aligned} i\hbar\frac{\partial\phi}{\partial t} &= \frac{1}{2m}\left(\frac{\hbar}{i\nabla} - \frac{e\mathbf{A}}{c}\right)^2(\phi + \chi) + (e\phi + mc^2)\phi \\ i\hbar\frac{\partial\phi}{\partial t} &= -\frac{1}{2m}\left(\frac{\hbar}{i\nabla} - \frac{e\mathbf{A}}{c}\right)^2(\phi + \chi) + (e\phi - mc^2)\phi\,. \end{aligned} \tag{3}$$

The merit of this formalism is that it enables us to give a particle interpretation to the usual wave-formalism (see [8] for further details.) However the advantage of the Feschbach Villars formalism is that we can now work with an ostensible particle interpretation.

In any case, we encounter the Compton scale again and again. Wigner [10] pointed out its remarkable universality.

From the above it is apparent that if an elementary particle in the above characterisation is bombarded with very high frequency radiation of the order of the Compton frequency such a particle would break up and yield its energy. What happens in this case is that the Bell curve becomes so compressed that it will be like a straight line or spike, almost (see [12, 13]). This sharp spike would break up the elementary particle releasing it's mass as energy.

It is well known in Quantum Mechanics that what may be called monochromatic waves are an idealization. This is in the sense that we have in general a wave packet made up of several frequencies [2]. But suppose we can single out a pure or nearly pure frequency? This is a technological problem. Let us start with the Schrodinger equation [2]:

$$\frac{d^2\psi}{dx^2} + \frac{p^2}{\hbar^2}\psi = 0$$

where

$$p = \sqrt{2m[E - V(x)]}\,.$$

This leads to

$$\phi(x)\,\exp\left(\pm\frac{i}{\hbar}\int^x p(x)dx\right) \tag{4}$$

where $\phi(x)$ is the solution of the free equation, and we already have a wave packet over different values of p or effectively frequencies. However, if we have a wave function like $\psi' = e^{ikx-pt}$, such a wave would be an extreme idealization and at the same time would be monochromatic. Can we achieve this, is the question. There has been recently some progress in this direction thanks to the experiment of Cruz-Chu and co-workers [1] who have been able to conduct an experiment where single particle X-ray diffraction patterns could be analysed thanks to a machine learning algorithm.

Remarks

What happens in this case is, the Bell curve becomes so compressed that it will be like a straight line. This sharp spike could break up the elementary particle releasing it's mass as energy. Fortunately, in recent years there has been some progress in this direction [11–13]. Furthermore, it may be pointed out that a pure monochromatic signal would be useful in communications as well. This is because, effectively the bandwidth would increase [14]. Finally, we observe that, if we can break up quarkonium particles, we can extract even greater energy. There is one way of doing this: we know that with $g = 2$ factor, there is a sort of precession and, if we could radiate with resonant frequencies, the particle would break up. This could be a technological problem.

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