Chapter 14

Photons, Vacuum Fluctuations, Multiverses and Gravitons

This chapter is to be taken with caution, because it will deal with some very speculative consequences, but also very interesting, of our approach of the perfect cosmological network.

The first part of this chapter is dedicated to *a discussion of pure transverse waves*, quantified in the form of photons. In chapter 3, we have shown that the propagation of a linearly polarized transverse "electromagnetic" rotation wave is accompanied by a longitudinal "gravitational" wavelet. In this chapter, we will focus on what happens in the case of localized wave packets. We will show that these wave packets can only appear with *a non-zero helicity* so that their total energy does not depend on time. Assuming that these wave packets are emitted when a topological singularity suddenly changes state, it becomes quite understandable that they present *a quantification of their energy*. These wave packets then behave like energetic quasi-particles of "electromagnetic" fluctuations which one could qualify as *"photons"* and which actually have properties very similar to the quantum properties of photons: circular polarization, zero mass, non-zero momentum, non-locality, wave-corpuscle duality, entanglement and phenomenon of decoherence.

The rest of the chapter is dedicated to some very hypothetical consequences of the perfect cosmological lattice, associated with *pure gravitational fluctuations*. One can imagine the existence of pure longitudinal fluctuations within the cosmological lattice which can be treated, either as random gravitational fluctuations which could have an analogy with *"quantum vacuum fluctuations"*, or as stable gravitational fluctuations, which could lead on a macroscopic scale to a *"cosmological theory of Multiverses"*, and on a microscopic scale to the existence of a form of stable quasi-particles which one could call *"gravitons"*, by analogy with photons, but which in fact have nothing in common with the gravitons usually postulated in the context of General Relativity.

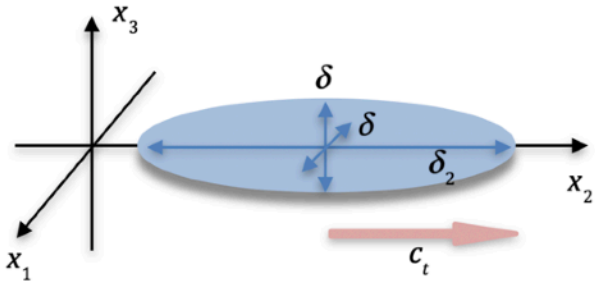
Transverse rotation wave packets: the photons

We saw in chapter 3 that the propagation of a linearly polarized transverse wave within the cosmological lattice is bound to the existence of a correlated perturbation of the expansion of the lattice, and that only the circularly polarized rotation waves are pure transverse waves, without associated expansion wavelets. One can reasonably wonder if this astonishing property could not be at the origin of the existence of *quantified "electromagnetic" fluctuations*, like the famous *photons* of quantum physics?

Let us consider transverse waves of pulsation Ω propagating along the axis Ox_2, with a polarization of the fields of rotation $\underline{\omega}_1(x_2,t)$ and $\underline{\omega}_3(x_2,t)$ and of the fields of velocity $\underline{\phi}_1(x_2,t)$ and $\underline{\phi}_3(x_2,t)$ along the axes Ox_1 and Ox_3. We then try to form a bundle of transverse waves, of pulsation Ω, of exponential envelopes of range δ_2 along the axis Ox_2 and of equal ranges $\delta_1 = \delta_3 = \delta$ along the axes Ox_1 et Ox_3. By applying linearized field equations for these

fluctuations in the domain $\tau_0 < \tau_{0cr}$, there appears a volume expansion component $\underline{\tau}^{(p)}(x_2,t)$ associated with the wave packet, of frequency 2Ω. If one calculates the energy density of this fluctuation by oscillations of the field of rotation and the field of expansion, it contains terms in $\cos^2 \Omega t$, in $\cos^2 2\Omega t$ and in $\cos 2\Omega t$, so that it is not independent of time, whereas it should be in principle. To make these terms in $\cos^2 \Omega t$, in $\cos^2 2\Omega t$ and in $\cos 2\Omega t$ disappear, so that the energy density of the fluctuation does not depend on time, and to make disappear the volume expansion component of the wave packet, a rather tedious calculation leads to the real solution of the wave packet proposed in figure 14.1.

This wave packet represents in fact, in the analogy with electromagnetism, a packet of electromagnetic waves, which *MUST* present a right or left helicity so that its energy is independent of time, and especially so that it is not accompanied by a "gravitational" disturbance of expansion. Knowing that $mnc_t^2 = K_3$ in the perfect cosmological lattice for $\tau_0 < \tau_{0cr}$, *the energy density* of this packet of wave is given by the relation reported in figure



Wave packet of circular polarization transverse waves not coupled with gravitational fluctuations

$$\begin{cases} \omega_1(x_2,t) = \omega_{10}\, e^{-\frac{|x_1|}{\delta}} e^{-\frac{|x_3|}{\delta}} e^{-\frac{|x_2-c_t t|}{\delta_2}} \cos\left[\frac{\Omega}{c_t}(x_2-c_t t)\right] \\ \omega_3(x_2,t) = (\mp)\omega_{10}\, e^{-\frac{|x_1|}{\delta}} e^{-\frac{|x_3|}{\delta}} e^{-\frac{|x_2-c_t t|}{\delta_2}} \sin\left[\frac{\Omega}{c_t}(x_2-c_t t)\right] \\ \phi_3(x_2,t) = -2c_t\omega_{10}\, e^{-\frac{|x_1|}{\delta}} e^{-\frac{|x_3|}{\delta}} e^{-\frac{|x_2-c_t t|}{\delta_2}} \cos\left[\frac{\Omega}{c_t}(x_2-c_t t)\right] \\ \underline{\phi}_1(x_2,t) = \{\mp\}2c_t\omega_{10}\, e^{-\frac{|x_1|}{\delta}} e^{-\frac{|x_3|}{\delta}} e^{-\frac{|x_2-c_t t|}{\delta_2}} \sin\left[\frac{\Omega}{c_t}(x_2-c_t t)\right] \end{cases}$$

Energy density

$$e^{fluctuation} = \underbrace{2K_3(\omega_1^2+\omega_3^2)}_{e_0^{kin}} + \underbrace{\frac{1}{2}mn(\phi_1^2+\phi_3^2)}_{e^{pot}} = 4K_3\omega_{10}^2\, e^{-2\frac{|x_1|}{\delta}} e^{-2\frac{|x_3|}{\delta}} e^{-2\frac{|x_2-c_t t|}{\delta_2}}$$

Total energy of the wave packet

$$E_{wave\ packet} = 8\int_0^\infty dx_1 \int_0^\infty dx_3 \int_0^\infty dy \left(4K_3\omega_{10}^2\, e^{-2\frac{x_1}{\delta}} e^{-2\frac{x_3}{\delta}} e^{-2\frac{y}{\delta_2}}\right) = 4K_3\omega_{10}^2\delta^2\delta_2$$

Figure 14.1 - *Wave packet of circular polarization transverse waves not coupled with gravitational fluctuations*

14.1. And by making a change of variable $x_2 - c_t t = y$, we can quite easily calculate the total energy of this fluctuation of the field of rotation, which is worth $E_{wave\ packet} = 4K_3\omega_{10}^2\delta^2\delta_2$. It can therefore be seen that this expression of the energy of the wave packet only depends on the maximum amplitude ω_{10} of the oscillations of the field of rotation and of the spans δ_2 along the axis Ox_2 and $\delta_1 = \delta_3 = \delta$ along the axes Ox_1 et Ox_3, and that the pulsation ω of the wave does not intervene in this expression of energy.

If we consider that the perfect cosmic lattice is indeed a theoretical representation of the real Universe, then the rotation wave packets that we have just described must probably correspond to photons. Assuming therefore that these wave packets are emitted when a topological singularity suddenly changes state (such as for example the level transition of an electron in an atom), it becomes very simple to explain that they present a quantification of their energy. Indeed, suppose a singularity which passes from a high energy level *(a)* to a lower energy level *(b)*, as illustrated in figure 14.2. Using the relations of figure 11.1 for the pulsation of the gravitational fluctuations, and by expressing these relations in the non-relativistic case, one has $\hbar\underline{\omega}_f^{(a)} = E_0^{dist} + V^{(a)}$ and $\hbar\underline{\omega}_f^{(b)} = E_0^{dist} + V^{(b)}$, so that the loss of energy of the singularity during its transition from level of energy is expressed as $\Delta E_{lost} = V^{(a)} - V^{(b)} = \hbar\left(\underline{\omega}_f^{(a)} - \underline{\omega}_f^{(b)}\right)$.

This energy ΔE_{lost} is dissipated in the form of a photon, therefore of a packet of transverse waves transporting this energy lost by the singularity. By equalizing the dissipated energy ΔE_{lost} with the total energy $E_{wave\ packet}$ of the transmitted wave packet, we obtain a relation between the parameters $\omega_{10}, \delta, \delta_2$ of the wave packet and the pulsation $\Omega_{wave\ packet}$ of the wave packet, in the form $E_{wave\ packet} = 4K_3\omega_{10}^2\delta^2\delta_2 = \hbar\left(\underline{\omega}_f^{(a)} - \underline{\omega}_f^{(b)}\right) = \hbar\Omega_{wave\ packet}$.

This relation is then quite remarkable, because it shows that *the energy of the transverse fluctuation is quantified with the value* $\hbar\left(\underline{\omega}_f^{(a)} - \underline{\omega}_f^{(b)}\right)$, and that *the frequency* $\Omega_{wave\ packet}$ *of the transverse fluctuation emitted is nothing other than the difference of the frequencies of the*

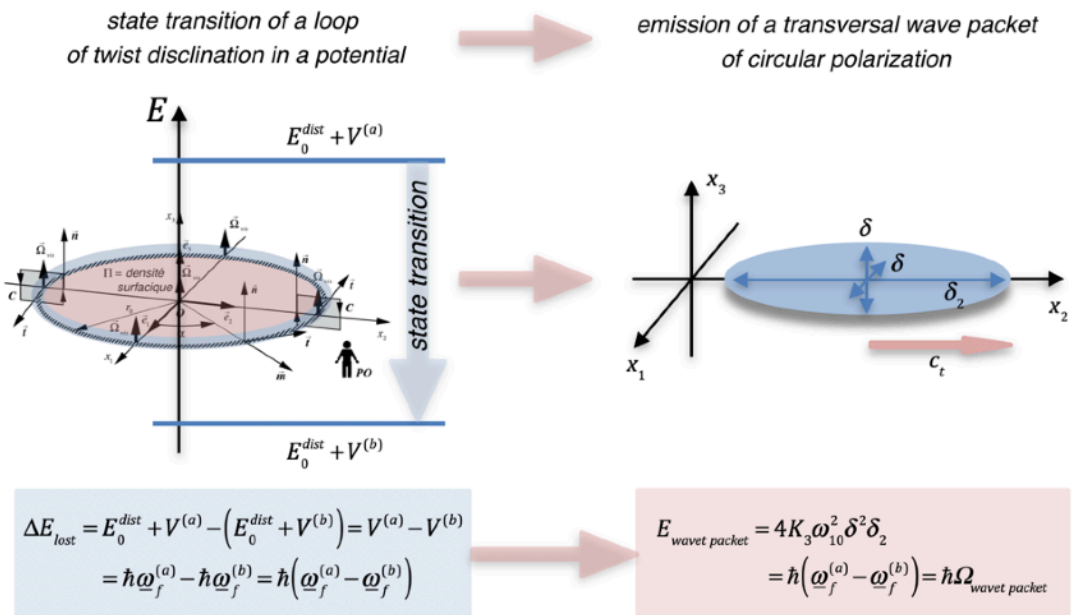


Figure 14.2 - *Emission of a packet of transverse waves of circular polarization by the state transition of a twist disclination loop in a potential*

gravitational perturbations of the singularity in states (a) and (b). We therefore find the experimental observation that the energy of photons is quantified, as Einstein initially proposed, and that the energy of a photon has a well-determined value proportional to its pulsation $\Omega_{wave\ packet}$ via the Planck constant.

About the possible properties of transverse rotation wave packets

- About the non-locality of the rotation wave packet:

The wave packet thus formed has a "volume" $\delta^2\delta_2$, an amplitude ω_{10} and an energy $E_{wave\ packet} = \hbar\Omega_{wave\ packet}$. As its energy is required to remain constant, this implies that neither the amplitude ω_{10} nor the "volume" $\delta^2\delta_2$ are predetermined, but that they are simply linked by the relationship $4K_3\omega_{10}^2\delta^2\delta_2 = \hbar\Omega_{wave\ packet}$. The wave packet thus presents a kind of *"malleability"*, or *"plasticity"*. It can for example lengthen or shrink along its axis of propagation Ox_2 , or extend or compress along the axes Ox_1 and Ox_3 perpendicular to the direction of propagation, or else extend or contract isotropically in the lattice, provided that the product $\omega_{10}^2\delta^2\delta_2$ remains a constant equal to $\hbar\Omega_{wave\ packet}/4K_3$.

If the wave packet is very picked up on itself, that is to say that its «volume" $\delta^2\delta_2$ is very small and that its amplitude ω_{10} is very large, it will then behave like *a localized quasi-particle of energy* $E_{wave\ packet} = \hbar\Omega_{wave\ packet}$. But during its propagation, it can also very well extend and occupy a very large «volume" $\delta^2\delta_2$, with a very low amplitude ω_{10} , and behave in this case rather like a wave, capable of all phenomena of interference and diffraction of a usual wave. We find here *the non-locality property* of the quasi-particle during its propagation, in the same sense as in quantum physics.

- About the momentum of the quasi-particle "photon":

In the form of a quasi-particle, that is to say when the wave packet is very contracted, therefore of very low "volume", it obviously has no mass of inertia, but it does have a non-zero momentum. We deduce this peculiarity from the fact that this wave packet moves at the speed c_t and therefore that it must satisfy *the relativistic equation of the energy* of figure 11.1, with a mass of inertia $M_0 = 0$, namely $\left(E_{\boldsymbol{v}}^{photon}\right)^2 = \left(\vec{\boldsymbol{P}}^{photon}\right)^2 c_t^2$, which implies a non-zero momentum $\vec{\boldsymbol{P}}^{photon} = \pm E_{\boldsymbol{v}}^{photon}\vec{e}_2/c_t = \pm\hbar\Omega\vec{e}_2/c_t$ in the propagation direction.

- About the wave-particle duality of the rotation wave packet:

These wave packets actually have a *wave-particle duality* similar to that observed in quantum physics. The only restriction imposed on this wave packet by the fact that it propagates in a cosmological lattice satisfyingt $\tau_0 < \tau_{0cr}$ is that it is obliged to remain *a single entity* of given energy and helicity, so that its energy $\hbar\Omega$ remains constant and that there is no expansion perturbations.

This implies that such a wave packet, if it is very large and that it must, for example, pass through a slot, must necessarily contract sufficiently to pass through the slot in the form of a single entity. But nothing prevents that during this crossing, the wave side of this entity interacts with the edges of the slit so that the entity is diffracted during this crossing, and therefore that the "trajectory" of this quasiparticle can be modified.

Similarly, if this extended wave packet encounters a double slit, it can cross the two slits by contracting locally, and recombine after this crossing, provided that its entity integrity has not

been modified during this crossing. But the recombination of the wave entity after the passage of the two slits is subject to wave interference, so that the probability of finding the quasi-particle in space after the slits presents fringes identical to conventional interference fringes for a plane wave passing through two slits.

This also implies that if the wave packet, very large during its propagation, begins to be absorbed by an obstacle, the maintenance of a constant energy over time forces it to contract again so that the absorption of its energy is a very localized phenomenon. We could reasonably speak here of the *"materialization" of the wave packet in the form of a "quasi-particle"*. It must therefore behave like a very localized quasi-particle during its creation or its annihilation.

Note that what is called *the "measurement problem" in quantum physics* corresponds exactly to this type of phenomenon. Any attempt to "touch" the wave packet will force it to change so that it remains an energy entity independent of time. Thus, a measurement on this wave packet is necessarily an action which will disturb this wave packet and modify its characteristics.

- About the creation of pairs of "photon" quasi-particles:

As the quasi-particle "photon" has a momentum due to its relativistic behavior, the creation of a single photon would violate the principle of momentum conservation. This implies that photons can only be created in pairs of photons of the same frequency, propagating in two opposite directions so that their overall momentum is zero.

- About the entanglement phenomenon of two virtual quasi-particles "photons":

Initially, when creating a pair of photons, there may well be only one locally created wave packet, in which case it must lengthen at the speed c_t on either side of the axis of propagation of the two virtual quasi-particles in order to ensure zero global momentum. You could say that the single wave packet of energy $2\hbar\Omega$ representing the two quasi-particles of momentum $\vec{P}^{photon} = \pm\left(\hbar\Omega / c_t\right)\vec{e}_2$ then corresponds to *an entangled state of the two virtual quasi-particles*. But if one end of this wave packet is suddenly "materialized" in the form of a quasi-particle (photon 1) transferring energy $E_{déposée} = \hbar\Omega$ to an "object" interacting with it, the second end of the wave packet will regroup and own the energy $E^{fluctuation} = \hbar\Omega$ and the momentum $\vec{P}^{photon} = \pm\left(\hbar\Omega / c_t\right)\vec{e}_2$. It will therefore necessarily transform into a wave packet representing photon 2, which can be "materialized" in the form of a quasi-particle.

But it should be noted that the initial wave packet had, at the time of the "materialization" of the first quasi-particle, a polarization and a helicity which could be measured, and that this polarization and this helicity measured then become the prerogative of the residual wave packet. This is exactly what quantum physics predicts when it talks about *the entanglement of two photons*. And there is therefore no instantaneous "transmission" of information from one quasi-particle (photon 1) to the other quasi-particle (photon 2) since it is during the "materialization" of the first quasi-particle (photon 1) that the wave packet associated with the second quasi-particle (photon 2) forms and necessarily acquires the characteristics complementary to the first quasi-particle (photon 1), characteristics which will be observed during of the "materialization" of the second quasi-particle (photon 2).

- About the phenomenon of decoherence:

As we have just said, a wave packet of energy $E^{fluctuation} = \hbar\Omega$ representing the two photons created initially can extend along a single axis over great distances. But this lengthening is obviously done at the expense of the amplitude ω_{10} of the wave packet. As the

wave packet lengthens, it will become more and more sensitive to its environment, that is to say to the other field fluctuations it encounters, until it encounters a sufficiently strong fluctuation to "break" the initial wave packet and divide it into two independent wave packets, which will therefore no longer be entangled. From this moment, the two wave packets become independent. We can then speak of a *phenomenon of decoherence*, in the sense that the "materialization" of the two wave packets in the form of two individual photons will no longer exhibit the entanglement effect described in the previous section.

This phenomenon is absolutely similar to the phenomenon of decoherence that quantum physics invokes to explain the passage from the microscopic quantum world to the classical macroscopic world.

Although quite speculative, the results obtained here are quite interesting, because they mean that the cosmological lattice which does not present longitudinal waves for $\tau_0 < \tau_{0cr}$ may contain localized disturbances of pure transverse waves of circular polarization which seem to have all the characteristics of photons (quantification, wave-particle duality, entanglement, etc.).

Localized longitudinal gravitational fluctuations

In figure 11.1, we have seen that, in a lattive in which the propagation of longitudinal waves is not possible, there can appear localized longitudinal vibrations, which one could call *localized gravitational fluctuations* $\tau^{(p)}_{localized}(\vec{r},t)$ since they are field fluctuations of the volume expansion. We can try to dig a little deeper into this subject, by describing these longitudinal fluctuations in a cosmological lattice containing neither topological singularities nor transverse waves.

In the absence of topological singularities and transverse waves, imagine the existence of fluctuations $\tau^{(p)}(\vec{r},t)$ of the volume expansion field of a cosmological lattice in the domain $\tau_0 < \tau_{0cr}$, of type $\tau(\vec{r},t) = \tau_0 + \tau^{(p)}(\vec{r},t)$. These fluctuations $\tau^{(p)}(\vec{r},t)$, if they exist, must obviously satisfy Newton's equation of the volume expansion field. In the absence of topological singularities and transverse waves, and neglecting the effects of vacancies and interstitials ($\vec{p} \cong m\vec{\phi}$), Newton's second partial equation for longitudinal perturbations is given by the relation of figure 5.1 in which we neglect all the fields apart $\tau^{(p)}$ and $\vec{\phi}^{(p)}$, and from which we take directly the divergence. By considering sufficiently small fluctuations $\tau^{(p)}(\vec{r},t)$, it is possible to linearize the equation, by completely neglecting the term $(\tau^{(p)})^2$ and by extracting the density n from the divergence term. We can also introduce a parameter α with value $\alpha = K_0 - 4K_2/3 - 2K_1(1+\tau_0)$, which is positive if the cosmological lattice does not present longitudinal waves, that is to say if $\tau_0 < \tau_{0cr}$, and replace the material derivative by the partial derivative of time, so that the equation is reduced to the first equation of figure 14.3. Still using the geometro-kinetic equation for volume expansion, assuming zero lattice sources, and neglecting the material derivative, we obtain the second equation in figure 14.3. By combining these two relations, we obtain the linearized Newton's equation of weak gravitational fluctuations in the cosmological lattice without propagation of longitudinal waves, in the domain $\tau_0 < \tau_{0cr}$.

If we dissociate the spatial behavior and the temporal behavior of these fluctuations $\tau^{(p)}(\vec{r},t)$, we can write them as the product of a spatial function $\hbar^2\psi(\vec{r})$ by an oscillating term $e^{-i\omega t}$ in time, in the form $\tau^{(p)}(\vec{r},t) \cong \hbar^2\psi(\vec{r})e^{-i\omega t}$. By introducing this writing of fluctuations into

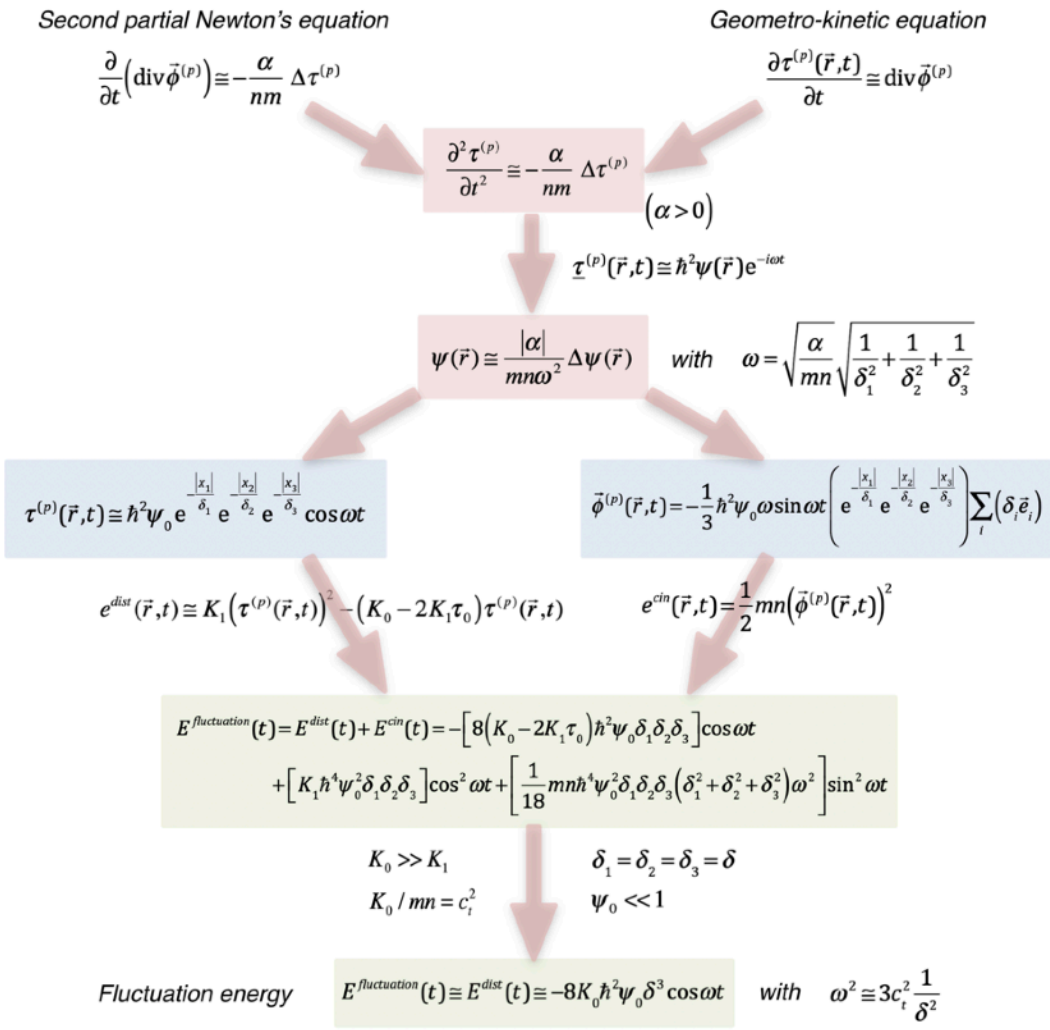


Figure 14.3 - *Energy of a localized gravitational fluctuation*

Newton's equation, we obtain the equation which governs the spatial component $\psi(\vec{r})$ when the fluctuations present a pulsation ω .

For example, suppose a fluctuation which is located in the vicinity of the origin, along the three axes of space. For such a fluctuation to satisfy the previous Newton's equation, the spatial component $\hbar^2\psi(\vec{r})$ must be written in the form of a symmetrical exponential decay on either side of the origin, which, introduced into the equation of Newton, makes it possible to connect the pulsation ω of the fluctuation to *its spatial ranges* δ_i according to the three directions of space. We therefore see that the pulsation of a gravitational fluctuation is then inversely proportional to its spatial ranges. We can easily deduce the spatial fluctuation $\tau^{(p)}(\vec{r},t)$, as well as the velocity fluctuation $\vec{\phi}^{(p)}(\vec{r},t)$ within the lattice.

Let's try to calculate the elastic energy stored by this perturbation in the lattice. The elastic energy density $e^{dist}(\vec{r},t)$ is given by the expression in figure 14.3 if the background expansion τ_0 of the cosmic lattice is not zero. The total elastic energy $E^{dist}(t)$ of the fluctuation is obtained by integrating $e^{dist}(\vec{r},t)$ over all of the space. The kinetic energy density $e^{cin}(\vec{r},t)$ of the fluctuation is given by the expression in figure 14.3, and the total kinetic energy $E^{cin}(t)$ of

the fluctuation is obtained by integrating $e^{cin}(\vec{r},t)$ over all of the space. We deduce the total energy of the fluctuation $E^{fluctuation}(t)=E^{dist}(t)+E^{cin}(t)$ reported in figure 14.3.

Random microscopic fluctuations and quantum vacuum fluctuations

Now consider microscopic longitudinal fluctuations, that is to say "gravitational" fluctuations for which the amplitude ψ_0 is extremely small. Let's discuss here the very simple case of an isotropic "gravitational" fluctuation, that is to say such that the ranges in the three directions of space are equal. In the case of the perfect cosmological lattice, for $\tau_0 < \tau_{0cr}$, we have that $K_0 >> K_1$ and $K_0 / mn = c_t^2$, so that, if this fluctuation is of very small magnitude $\psi_0 << 1$, it is *the energy of distortion associated with* K_0 which largely dominates the others, and therefore that $E^{fluctuation}(t) \cong E^{dist}(t) \cong -8K_0\hbar^2\psi_0\delta^3\cos\omega t$.

This result of a fluctuating energy which is symmetrically positive or negative over time is quite interesting and intriguing. It indeed means that a lattice not presenting longitudinal waves could be subjected to *a superposition of local fluctuations* of various pulsations ω_k, various

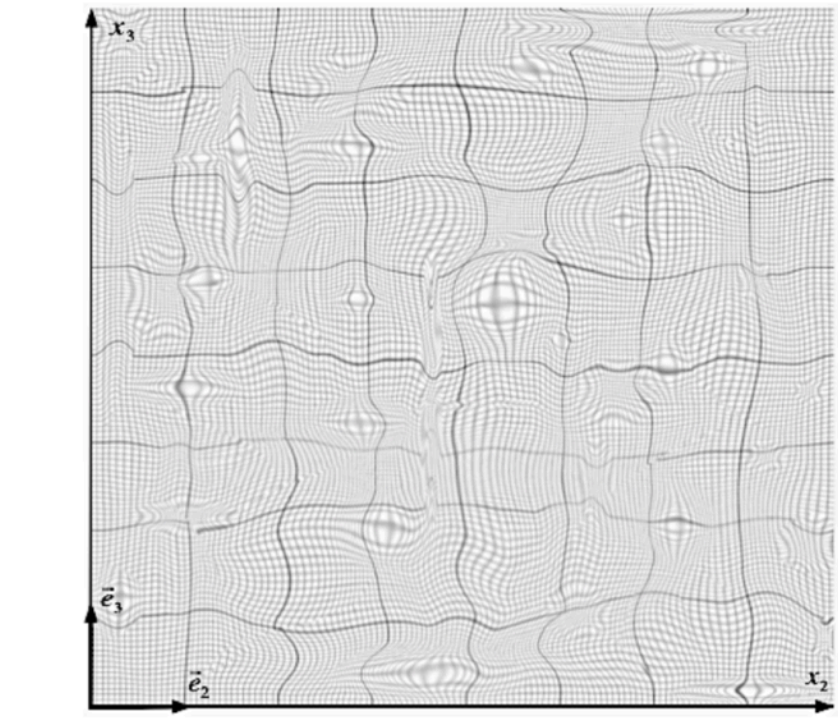


Figure 14.4 *- Schematic representation of the field* $\tau^{(p)}(\vec{r},t)$ *of elementary "gravitational" fluctuations*

phases φ_k and various amplitudes ψ_{0k}, and whose centers would be located randomly at the positions $\vec{r}_k$, so as *to take instantly the mathematical look* shown in figure 14.4.

And since the energy of each of these fluctuations can be positive or negative over time, with a zero average, the instantaneous global energy of *this field would always have zero energy on average*. We can try to schematically represent this situation in the lattice, as we did in figure 14.4.

This field of microscopic "gravitational" fluctuations is obviously not formed of stable fluctuations in time since their energy is not a constant. It is in fact made up of *"evanescent" fluctuations*, which appear and disappear spontaneously, while maintaining a zero global energy of the cosmological lattice. As such, this field of “gravitational” fluctuations is the perfect analog of *the field of quantum fluctuations of the vacuum*, also composed of quantum fluctuations on the microscopic scale, of positive and negative energies, but whose average energy remains zero.

In the presence of such a superposition of fluctuations, we can calculate the product of $\tau^{(p)}(\vec{r},t)$ by its complex conjugate. When expressing this product, it appears many terms, some having a zero value because of the positive and negative random values of the products $e^{i(\omega_n-\omega_m)t}e^{i(\varphi_n-\varphi_m)}$ and some having a non-zero value because they represent the sum of the squares of the amplitudes of each fluctuation. We thus obtain a nonzero product which is nothing other than the instantaneous product of the wave function $\psi(\vec{r},t)$ by its complex conjugate as illustrated in figure 14.4. In chapter 1, we interpreted the product $\underline{\psi}(\vec{r},t)\bullet\underline{\psi}^*(\vec{r},t)$ as the probability of the presence of a topological singularity responsible for the wave function $\psi(\vec{r},t)$. We can therefore apply this probabilistic concept here and imagine that the nonzero instantaneous value of $\psi(\vec{r},t)\bullet\psi^*(\vec{r},t)$ corresponds to *a probability of the presence of a virtual topological singularity*, in other words a topological singularity which does not really exist, which perfectly matches the usual interpretation of the quantum vacuum fluctuations in quantum physics.

Is it possible to form stable oscillatory gravitational fluctuations?

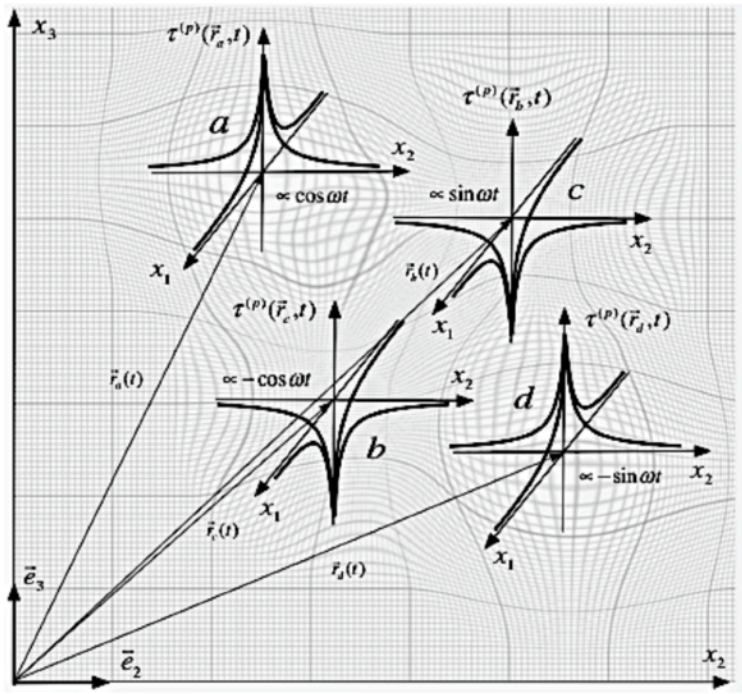
To form stable gravitational fluctuations presenting themselves as localized and lasting longitudinal oscillations within the cosmological lattice, the total energy $E^{fluctuation}(t)$ of the single fluctuation in figure 14.3 poses a serious problem. Indeed, if the fluctuation must be a stable localized vibration of frequency ω, it should in principle have an oscillation energy $E^{fluctuation}(t)$ independent of time, which is obviously not the case of the expression of figure 14.3, since this expression depends at the same time on $\cos\omega t$, on $\cos^2\omega t$ and on $\sin^2\omega t$.

It is therefore necessary to imagine an *ad hoc* mechanism which can ensure the independence of the total energy $E^{fluctuation}(t)$ over time. In fact, it can be shown by fairly long and tedious calculations that the total fluctuation must be composed of at least four individual elementary fluctuations *a, b, c* and *d,* of the same frequency ω, and located in different places of the lattice, respectively in $\vec{r}_a(t)$, $\vec{r}_b(t)$, $\vec{r}_c(t)$ and $\vec{r}_d(t)$, as described in figure 14.5. And so that these four fluctuations together present a total energy independent of time, the various ranges of the four fluctuations must satisfy conditions which are reported in figure 14.5, where the product ABC of any three numbers is in fact proportional to *the "volume"* occupied by each fluctuation within the lattice. In this case only, we obtain a fairly simple expression of the total

energy independent of the time of the four fluctuations, which is essentially composed of *kinetic energy*, and this global fluctuation is then stable over time.

Stable macroscopic gravitational oscillations
in an infinite cosmological lattice and Multiverses

In the domain of the cosmological lattice in which there are no longitudinal waves, there is thus the possibility of seeing *a stable macroscopic fluctuation* appear formed of a quadruplet of elementary fluctuations, like that represented in figure 14.5, which represent local longitudinal vibrations at a given frequency ω , and in such a way that the total energy of the global fluctuation, essentially of kinetic nature, does not depend on time.



$$\tau^{(p)}(\vec{r},t) \equiv \hbar^2 \psi_0 \begin{bmatrix} +e^{-\frac{|x_1-x_{a1}(t)|}{\delta_{a1}}} e^{-\frac{|x_2-x_{a2}(t)|}{\delta_{a2}}} e^{-\frac{|x_3-x_{a3}(t)|}{\delta_{a3}}} \cos\omega t - e^{-\frac{|x_1-x_{b1}(t)|}{\delta_{b1}}} e^{-\frac{|x_2-x_{b2}(t)|}{\delta_{b2}}} e^{-\frac{|x_3-x_{b3}(t)|}{\delta_{b3}}} \cos\omega t \\ \pm e^{-\frac{|x_1-x_{c1}(t)|}{\delta_{c1}}} e^{-\frac{|x_2-x_{c2}(t)|}{\delta_{c2}}} e^{-\frac{|x_3-x_{c3}(t)|}{\delta_{c3}}} \sin\omega t \mp e^{-\frac{|x_1-x_{d1}(t)|}{\delta_{d1}}} e^{-\frac{|x_2-x_{d2}(t)|}{\delta_{d2}}} e^{-\frac{|x_3-x_{d3}(t)|}{\delta_{d3}}} \sin\omega t \end{bmatrix}$$

$$\text{with} \begin{cases} \omega \equiv c_t \sqrt{\frac{1}{A^2}+\frac{1}{B^2}+\frac{1}{C^2}} \\ \delta_{a1}\delta_{a2}\delta_{a3} = \delta_{b1}\delta_{b2}\delta_{b3} = \delta_{c1}\delta_{c2}\delta_{c3} = \delta_{d1}\delta_{d2}\delta_{d3} = ABC \end{cases}$$

$$E^{fluctuation} \equiv E^{cin} \equiv \frac{K_0}{9}\hbar^4\psi_0^2 ABC\left(A^2+B^2+C^2\right)\left(\frac{1}{A^2}+\frac{1}{B^2}+\frac{1}{C^2}\right)$$

Figure 14.5 *- Schematic representation of the four elementary fluctuations, components of a gravitational fluctuation with kinetic energy independent of time*

Consider then the case of a macroscopic fluctuation composed of a quadruplet of elementary quasi-isotropic fluctuations, that is to say with $\delta_{x1} \cong \delta_{x2} \cong \delta_{x3} \cong \delta$. From the relationships in figure 14.5 we deduce the pulse frequency $\omega \cong c_t \sqrt{3}/\delta$ of this macroscopic fluctuation, which is inversely proportional to the range δ , as well as the energy $E^{fluctuation} \cong E^{cin} \cong K_0 \hbar^4 \psi_0^2 \delta^3$ of the fluctuation which is essentially kinetic in nature. We deduce that macroscopic gravitational fluctuations of large amplitudes ψ_0 in the domain $\tau_0 < \tau_{0cr}$ would have a frequency of pulsation ω proportional to the inverse of their range δ and that their overall energy would be proportional to the product of the square ψ_0^2 of their amplitude and to their volume δ^3 , and independent of their pulsation ω .

In a perfect cosmological lattice which *would be of infinite size*, it is not possible to envisage a cosmological expansion like that which we described in chapter 3 (figures 3.7 to 3.10) in the case of a finite perfect cosmological lattice. On the other hand, one could imagine the appearance of a macroscopic fluctuation like that which we have just described in figure 14.5, which would be of gigantic volume δ^3 , so that its frequency ω of oscillation would be extremely low. And if its amplitude ψ_0 were also high enough, for tiny ***HS*** observers who would be placed within one of these elementary fluctuations, this one would have all the characteristics of a Universe which would oscillate between a maximum expansion and a maximum contraction with the pulsation ω . Thus, the set of the four elementary fluctuations could represent a *Multiverse.* And within each of these elementary fluctuations, that is to say of each of the four universes, the observations of ***HS*** would be very similar to those made by ***HS*** who would be placed within a Universe such as those described in chapter 3 in the case of a finite perfect cosmological lattice.

But for that, there are necessary conditions which can be deduced from figure 14.6 and which would be essentially the following:

(i) that the infinite cosmological lattice has a background expansion τ_0 such that $\tau_0 >> 1$ in order to ensure that the formation of lacunar black holes occurs in the gray area (in figure 14.6) where the expansion of this Universe takes place at increasing speed,

(ii) that the amplitude ψ_0 of the oscillation around $\tau = \tau_0$ is sufficient for the oscillation to pass through the range of values situated around $\tau \approx 0$ so that the cosmology scenario presented in chapter 10 is also applicable to these Multiverses.

Under these two conditions, each of these multi-universes then presents an expansion starting with a kind of “big-bounce”, but which no longer implies that the volume expansion passes through a singularity such that $\tau \to -\infty$, with, in the vicinity of its center, a cosmological evolution similar to that described in chapter 10, presenting a phase with an expansion at increasing speed during which the lacunar black holes are formed, then a phase with expansion at decreasing speed leading to the maximum expansion, which can or not go through an expansion domain located beyond the critical expansion value τ_{0cr} where longitudinal waves appear at the expense of localized longitudinal fluctuations. Then this universe would go through a phase of contraction leading it to a new "big-bounce". However, it is clear that the complete calculation of the behavior of such Multiverses is not as simple as the calculation which we have just presented, if only by the fact that we adopted the assumption that $\tau_0 << \tau_{0cr}$ in our calculations, which would obviously not be an appropriate hypothesis in the case of gigantic gravitational fluctuations that can form such multiverses.

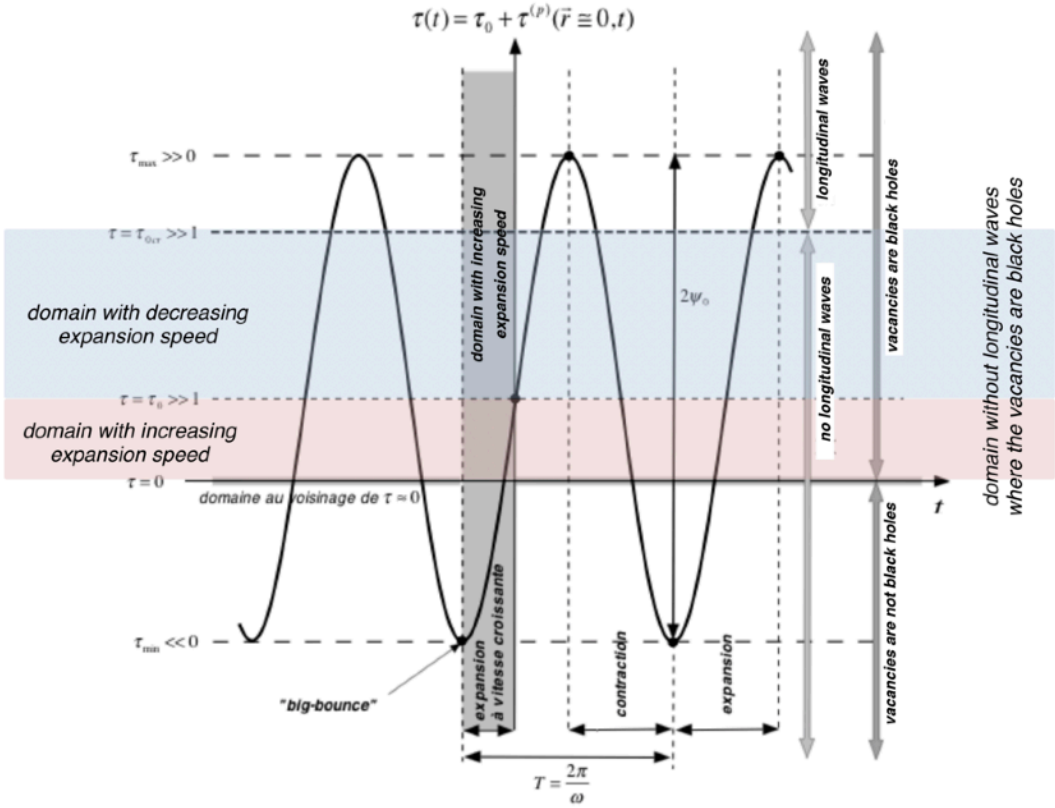


Figure 14.6 *- Expansions-contractions of one of the Multiverses. Behaviors of the gravitational forces of interaction between topological singularities correspond to those shown in figure 10.2*

Quantified microscopic gravitational oscillations: the "gravitons"

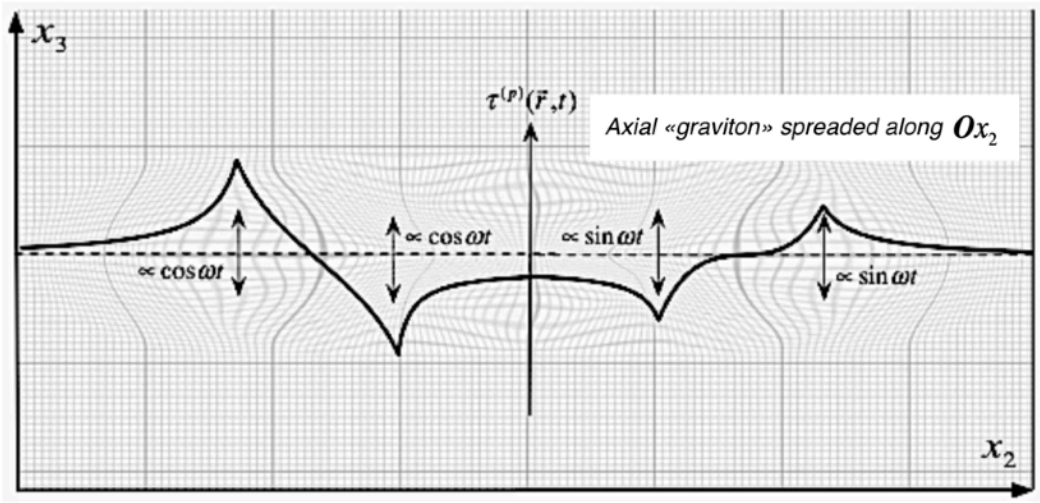
Let us now consider *stable microscopic longitudinal fluctuations*, that is to say "gravitational" fluctuations of the type described in figure 14.5, of constant energy, but for which the amplitude ψ_0 would be extremely small.

Let us consider here only the very simple case of an *isotropic* stable "gravitational" fluctuation, that is to say such that the ranges in the three directions of space are equal, and suppose very hypothetically that the constant energy of this is *quantified* in the same way as photons (the "electromagnetic" transverse fluctuations) were quantified, using the conjecture 11 introduced previously. By introducing the quantized energy $2\hbar\omega$ corresponding to the four degrees of freedom of oscillations of the fluctuation, one obtains a stable, localized and quantified fluctuation, of kinetic energy $E^{fluctuation} \cong E^{cin} \cong K_0 \hbar^4 \psi_0^2 \delta^3 = 2\hbar\omega$, of pulsation ω, of ranges δ_{ij}, and whose amplitude ψ_0 is given in figure 14.7

This quantified stable fluctuation would therefore have spatial extensions δ_{ij} dependent on its pulsation ω, as well as an energy proportional to its pulsation ω and an amplitude linked to the spatial extensions δ_{ij}. This fluctuation would not need to move within the lattice, even if it could wander within the lattice. It is therefore a quasi-particle in the same way as the photon in the case of transverse "electromagnetic" waves of rotation, but it is a quasi-particle which is

associated with longitudinal "gravitational" vibrations of expansion of the lattice. We could therefore speak in this case of

In fact, these gravitons have nothing to do with the gravitons sought in the context of quantification tests of general relativity. The gravitons postulated in our approach are stable energetic quasi-particles, which can travel within the lattice, but which are not required to move at the speed of transverse waves, unlike the gravitons of general relativity which are supposed to be moving at the speed of light. In addition, our gravitons are not carriers of the gravitational interaction between two singularities, but only localized and quantified energy fluctuations of the expansion field, unlike the gravitons of general relativity, which are considered as the mediating particles of gravitational interaction.



$$\tau^{(p)}(\vec{r},t) \equiv \hbar^2 \psi_0 \begin{bmatrix} +e^{-\frac{|x_1-x_{a1}(t)|}{\delta_{a1}}} e^{-\frac{|x_2-x_{a2}(t)|}{\delta_{a2}}} e^{-\frac{|x_3-x_{a3}(t)|}{\delta_{a3}}} \cos\omega t - e^{-\frac{|x_1-x_{b1}(t)|}{\delta_{b1}}} e^{-\frac{|x_2-x_{b2}(t)|}{\delta_{b2}}} e^{-\frac{|x_3-x_{b3}(t)|}{\delta_{b3}}} \cos\omega t \\ \pm e^{-\frac{|x_1-x_{c1}(t)|}{\delta_{c1}}} e^{-\frac{|x_2-x_{c2}(t)|}{\delta_{c2}}} e^{-\frac{|x_3-x_{c3}(t)|}{\delta_{c3}}} \sin\omega t \mp e^{-\frac{|x_1-x_{d1}(t)|}{\delta_{d1}}} e^{-\frac{|x_2-x_{d2}(t)|}{\delta_{d2}}} e^{-\frac{|x_3-x_{d3}(t)|}{\delta_{d3}}} \sin\omega t \end{bmatrix}$$

with

$$\begin{cases} E^{fluctuation} \equiv E^{cin} = 2\hbar\omega = 2\hbar c_t \sqrt{\frac{1}{A^2}+\frac{1}{B^2}+\frac{1}{C^2}} \\ \delta_{a1}\delta_{a2}\delta_{a3} = \delta_{b1}\delta_{b2}\delta_{b3} = \delta_{c1}\delta_{c2}\delta_{c3} = \delta_{d1}\delta_{d2}\delta_{d3} = ABC \\ \omega \equiv c_t \sqrt{\frac{1}{A^2}+\frac{1}{B^2}+\frac{1}{C^2}} \\ \psi_0 = 6 \sqrt{\frac{c_t}{2\hbar^3 K_0 ABC\left(A^2+B^2+C^2\right)\sqrt{\frac{1}{A^2}+\frac{1}{B^2}+\frac{1}{C^2}}}} \end{cases}$$

Figure 14.7 *- Very schematic equations and representation of a quasi-particle "graviton"*

The configuration of the four elementary fluctuations making up the “graviton” quasi-particle can be very complex. The only condition obviously being that the four elementary fluctuations can exchange energy between them in order to keep the total kinetic energy constant. One could for example imagine axial "gravitons", that is to say quasi-particles for which the four

elementary fluctuations would be aligned along a preferential axis, an illustration of which is shown in figure 14.7. There is shown very schematically the case of a hypothetical axial "graviton" in the case where it is very spread out along the axis Ox_2. In this representation, we have graphically reported the instantaneous local volume expansion of the "graviton", by specifying the oscillations of the four components in $\cos\omega t$ and $\sin\omega t$.

It can be seen that the spreads δ_{ij} of the fluctuation along the different axes are constrained so that the products for each of the partial fluctuations are constant and equal. But each spread is not fixed, so that this quasi-particle can deform by spreading or shrinking along all the axes. For example, an axial "graviton" of pulsation ω, and therefore of kinetic energy $2\hbar\omega$, can very well oscillate between a very condensed form along the axis Ox_2 and very extended along the axes Ox_1 and Ox_3, and an opposite shape, very extended along the axis Ox_2 and very condensed along the axes Ox_1 and Ox_3. This effect is again clearly an aspect of the famous non-locality of quantum physics, as it has been described in the case of photons.

Finally, note that these hypothetical "graviton" quasi-particles are very different from the hypothetical evanescent gravitational fluctuations analogous to the quantum vacuum fluctuations described in figure 14.4. Indeed, in the case of evanescent gravitational fluctuations, the energy of the fluctuation is essentially *an energy of elastic distortion* associated with the modulus K_0 of the cosmological network, oscillating between a positive and negative value, and of zero mean value, while the energy of the hypothetical quasi-particles “gravitons” is *essentially kinetic in nature* and has a constant and not zero value, which ensures their long-term stability. And to obtain this stability, the quasi-particle must be composed of four strongly correlated and indissociable fluctuations which ensure the constancy of energy, in the same way as the quasi-particles “photons” must be composed of two perpendicular rotation fluctuations and out of phase, giving them their helicity and thus ensuring the constancy of their energy. There is therefore a strong analogy between quasi-particles "photons" and "gravitons", not only by their constitution ensuring the constancy of their energy, but also by their non-locality, namely their ability to spread in space while preserving their identity and their energy, a property which is a typical prerogative of quantum physics.