Chapter 10

Matter-antimatter asymmetry and its cosmological evolution

Within the framework of our analogy with the great theories of physics, we begin in this chapter, *essentially qualitative and prospective*, by emitting some hypotheses concerning the constitution of the matter and the anti-matter by supposing that particles and anti-particles are made up of clusters of topological singularities in loops (of twist disclination, edge dislocation and mixed dislocation) of a perfect cosmological lattice. The weak asymmetry between matter and anti-matter is introduced by assuming that matter is based on edge loops of interstitial nature and that anti-matter is based on edge loops of lacunar nature. Using the results of chapter 8, we will see that the interactions of gravitational nature between particles and anti-particles of the Universe are almost all attractive, while presenting a weak gradation of the intensities of interaction according to the type of interacting particles. Only the interaction forces which involve a prismatic edge loop of interstitial nature, which will be interpreted as a neutrino, have a repulsive nature.

Based on the cosmological behaviors of lattice expansion and gravitational interactions between topological singularities, we can imagine *a very plausible scenario for the cosmological evolution of topological singularities* leading to the current structure of our Universe. This scenario is based entirely on the fact that, in the case of the simplest edge dislocation loops, analogously similar to *neutrinos, the mass of curvature dominates the mass of inertia*, so that neutrinos should be the only gravitational repellant particles, while the anti-neutrinos would be gravitatively attractive. This assertion then makes it possible to give a simple explanation to several facts still very poorly understood in the evolution of matter in the Universe. *The formation of galaxies* could correspond to *a phenomenon of precipitation* of matter and antimatter *within a sea of repellant neutrinos*. *The disappearance of anti-matter* could correspond to *a phenomenon of segregation* of particles and antiparticles within galaxies, due to their slight difference in gravitational properties, segregation during which the antiparticles would regroup in the center of the galaxies to finally form *gigantic black holes in the heart of galaxies*. Even the famous *"dark matter"* that astrophysicists had to invent to explain the abnormal gravitational behavior of the periphery of galaxies would then be very well explained in our approach. Indeed, "dark matter" would be in fact the sea of repellant neutrinos in which the galaxies have precipitated and bathed, which, by the compressive force which it exerts on the periphery of the galaxies, would explain the abnormal gravitational behavior of the stars in the galaxy peripheries. Finally, we also show how we can easily treat *the Hubble constant*, *the "redshift" of galaxies* and *the evolution of the cosmic microwave background* in the framework of our approach.

About the constitution and the asymmetry of matter and anti-matter

The existence of 15 different “gravitational” interaction forces depending on the nature of the singularities involved in the table in figure 8.9, as well as the behavior of these forces as a function of the background expansion of the lattice illustrated in the figure 8.10, allow us to develop a fairly simple and entirely plausible scenario of the cosmological evolution of our Universe.

Let's start from conjecture 8, which stipulated that the singularities of a vacancy nature correspond by analogy to anti-matter and the singularities of interstitial nature to matter, to introduce the following hypotheses:

- the particles of matter (electron e^-, neutrino ν^0, neutron n^0, proton p^+, etc.) of the Universe would be made up of assemblies of loops of twist disclination, which give them their electrical charge, of loops of mixed dislocation, which give them their electric dipolar field, and prismatic edge dislocation loops of *interstitial* nature, which give them *a negative curvature charge*,
- the particles of anti-matter (positron $\overline{e}^+$, anti-neutrino $\overline{\nu}^0$, anti-neutron $\overline{n}^0$, anti-proton $\overline{p}^-$, etc.) of the Universe would be made up of assemblies of twist disclination loops, which give them their electrical charge, of loops of mixed dislocation, which give them their dipolar electric field, and of loops of prismatic edge dislocation of *vacancy* nature, which give them *a positive charge of curvature*.

If we accept this distinction between particles and anti-particles, the positive or negative curvature charge due to the component of edge loops of interstitial or vacancy nature, which appears neither in General Relativity, nor in the Standard Model of elementary particles, introduces *a weak asymmetry between particles and anti-particles which exists only in our approach*. This asymmetry is reminiscent of the asymmetry observed experimentally between particles and anti-particles in Particle Physics, without us knowing very well what cause attributed to it. This asymmetry affects certain properties of elementary particles (such as the violation of ***CP*** symmetry, combined action of a charge conjugation ***C*** and a symmetry by reflection ***P***), but not the rest mass of these particles (linked to the non violation of ***CPT*** symmetry, combined action of charge conjugation ***C***, reflection symmetry ***P*** and time inversion ***T***). However, in current physics, whether it is Particle Physics or General Gravitation, there is never any mention of the property of curvature charge, since this can only appear by the approach of the topological singularities of a lattice that we have developed in this book. This property of curvature charge specific to lattice topological singularities could therefore be an excellent candidate to explain the asymmetry observed experimentally between particles and anti-particles of matter.

To simplify the rest of this talk, let's now call the various particles with a generic name according to their type:

- *particle* X *or* Y a particle of matter such as an electron e^-, a muon μ^-, a tauon τ^-, a neutron n^0, a proton p^+ (or any other elementary particle composed of quarks) which involves twist disclination loops, therefore electrical charges, possibly loops of mixed dislocation in the event of a dipolar electric field and predominantly interstitial edge dislocation loops, therefore *a negative curvature charge*,
- *anti-particle* $\overline{X}$ *or* $\overline{Y}$ an anti-matter particle such as a positron $\overline{e}^+$, an anti-muon $\overline{\mu}^+$, an anti-tauon $\overline{\tau}^+$, an anti-neutron $\overline{n}^0$, an anti-proton $\overline{p}^-$ (or any other particle composed of quarks)

which involves loops of twist disclination, therefore electrical charges, possibly mixed dislocation loops in the event of a dipolar electric field, and predominantly edge dislocation loops of a vacancy nature, therefore *a positive curvature charge*,

- *neutrino* ν^0 a particle of matter corresponding to the electron neutrino ν_e, to the muonic neutrino ν_μ or to the tau neutrino ν_τ, which does not involve any loops of twist disclination and loops of mixed dislocation, but only loops of prismatic edge dislocation of interstitial nature, therefore *a negative charge of curvature*,

- *anti-neutrino* $\overline{\nu}^0$ a particle of anti-matter corresponding to the electronic anti-neutrino $\overline{\nu}_e$, to the muonic anti-neutrino $\overline{\nu}_\mu$ or to the tau anti-neutrino $\overline{\nu}_\tau$, which does not involve loops of twist disclination and loops of mixed dislocation, but only loops of prismatic edge dislocation of a vacancy nature, therefore *a positive curvature charge*.

To these 4 types of particles or anti-particles, we can, thanks to the previous chapters, assign masses of inertia and equivalent masses of curvature, which satisfy the mass relationships indicated in figure 10.1 in the case of particles and anti-particles, and in the case of neutrinos and anti-neutrinos.

Thus, without first knowing the exact constitution in terms of singularity loops of the various particles and anti-particles, we can deduce thanks to these relationships between masses of inertia and masses of curvature, very relevant information about the behavior of gravitational forces of interaction between these various particles. Indeed, in the case of the interaction between particles X and anti-particles $\overline{X}$, we have, thanks to table 10.1, the following inequality relations $\boldsymbol{F}_{grav}^{X-X} < \boldsymbol{F}_{grav}^{X-\overline{X}} < \boldsymbol{F}_{grav}^{\overline{X}-\overline{X}}$ between the gravitational interaction forces. As the mass of curvature is much lower than the mass of inertia $M_{curvature}^{\overline{X}} << M_0^{\overline{X}}$ in the case of a particle or an anti-particle which is not a neutrino, the difference between these interaction forces remains small, but it ensures still an asymmetry between particles and anti-particles (gravitationally, particles attract a little less strongly than anti-particles) which could play an important role in the cosmological evolution of the Universe, as we will see in the next section.

In the case of the interaction between particles X and Y, we have the following inequality relations $\boldsymbol{F}_{grav}^{X-Y} < \boldsymbol{F}_{grav}^{\overline{X}-Y} \cong \boldsymbol{F}_{grav}^{X-\overline{Y}} < \boldsymbol{F}_{grav}^{\overline{X}-\overline{Y}}$ between the gravitational interaction forces which again show that particles attract a little less strongly than anti-particles.

As for the cases which involve only neutrinos, the following relationships are deduced for the interaction forces: $\boldsymbol{F}_{grav}^{\nu^0-\nu^0} < 0$, $\boldsymbol{F}_{grav}^{\overline{\nu}^0-\overline{\nu}^0} > 0$, $\boldsymbol{F}_{grav}^{\nu^0-\overline{\nu}^0} \cong 0$, $\boldsymbol{F}_{grav}^{\nu^0-\nu^0} = -\boldsymbol{F}_{grav}^{\overline{\nu}^0-\overline{\nu}^0}$. In other words, neutrinos repel each other with a force of the same magnitude as anti-neutrinos attract. As for the interaction between a neutrino and an anti-neutrino, it is extremely weak since it involves the product $(M_0^{\nu^0})^2$.

Finally, with regard to the interactions between particles and neutrinos, the following relationships are obtained: $\boldsymbol{F}_{grav}^{X-\nu^0} < 0$, $\boldsymbol{F}_{grav}^{X-\overline{\nu}^0} \cong 0$, $\boldsymbol{F}_{grav}^{\overline{X}-\nu^0} \cong 0$, $\boldsymbol{F}_{grav}^{\overline{X}-\overline{\nu}^0} > 0$. So the interaction between a neutrino and a particle is repulsive. Between an anti-neutrino and an anti-particle, it is attractive. And between a neutrino and an anti-particle, or between an anti-neutrino and a particle, the interaction can be slightly positive or negative, but of lesser magnitude than in the first two cases.

Effects of the cosmological expansion of the lattice on gravitational interactions

With the relations of inequality between gravitational interaction forces that we have just

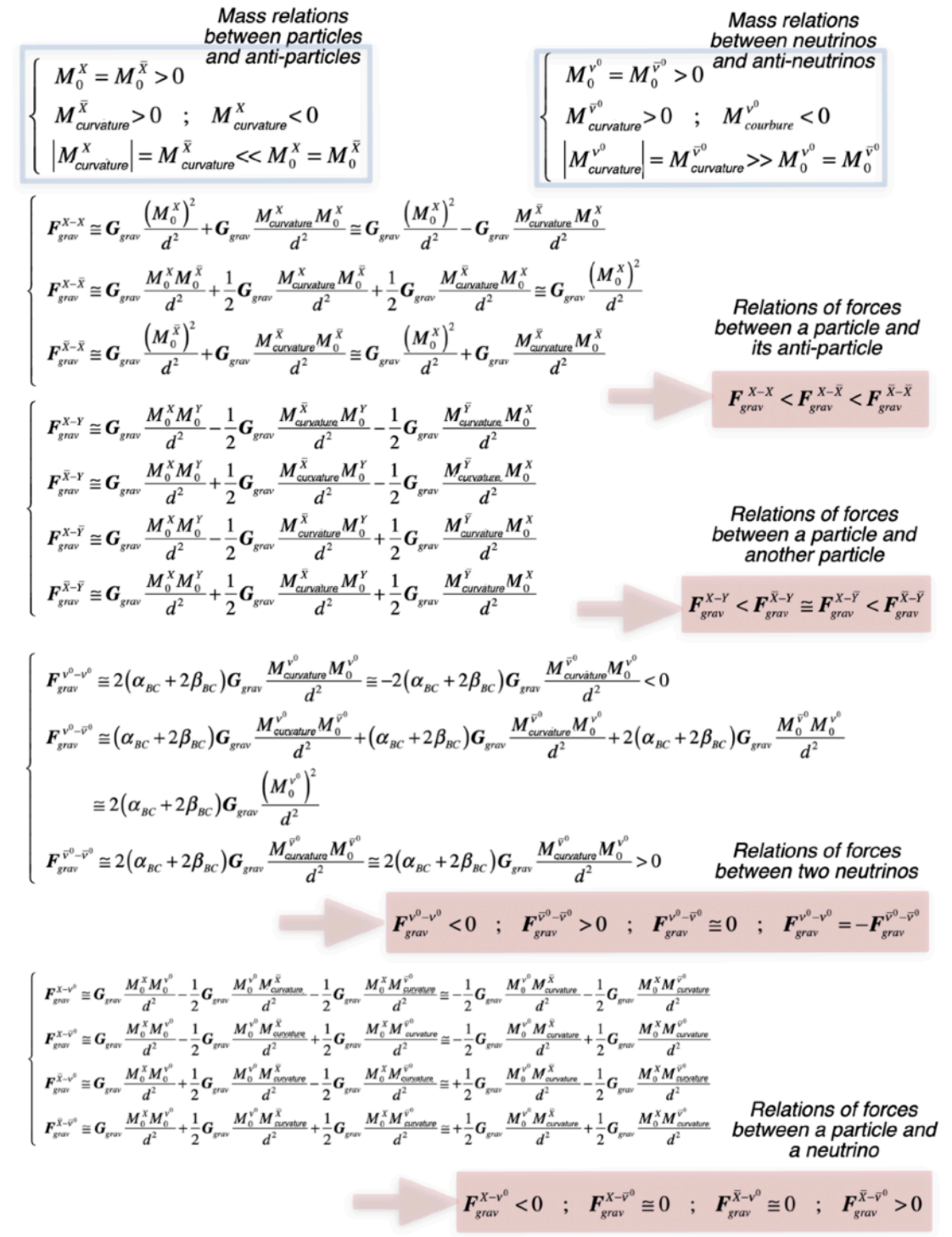

Figure 10.1 *- Relations of masses and interaction forces between particles (X or Y), antiparticles ($\overline{X}$ or $\overline{Y}$), neutrinos (ν^0) and antineutrino ($\overline{\nu}^0$)*

obtained for the interactions between particles, anti-particles, neutrinos and anti-neutrinos, we can return to the cosmological evolution of the perfect cosmological network (figure 3.7 and 3.10), and integrate into it the behaviors of the gravitational forces of interaction between particles. We obtain the result of figure 10.2.

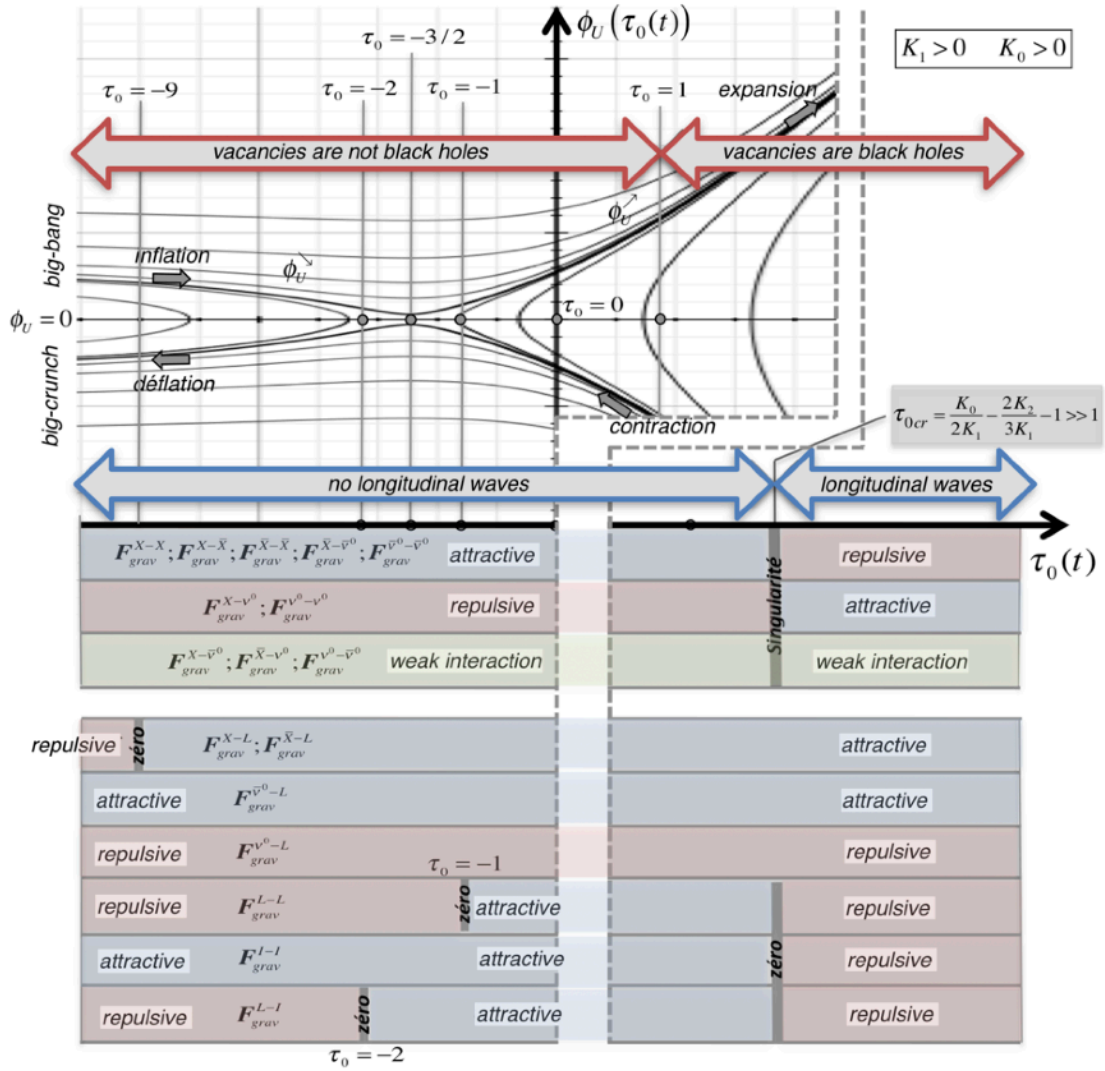

Figure 10.2 *- Behavior of "gravitational" interaction forces as a function of the cosmological evolution of the lattice background expansion*

As this figure shows, a series of values characteristic of expansion $\tau_0(t)$ appears for which there are sudden changes, either in the behavior of cosmological expansion, or in the behavior of the various gravitational interaction forces. In this figure, we have also reported the gravitational interaction forces involving macroscopic vacancies (black holes as soon as $\tau_0(t) \geq 1$) and macroscopic interstitials (neutron stars). Among the important characteristic values of the cosmological expansion of the lattice are:

- $\tau_0(t \to t_{init}) \to -\infty$, which represents *the initial "big-bang"* of the lattice over time t_{init},
- $\tau_0(t) = -9$, which represents the expansion value for which the interaction force between a macro vacancy and a particle or an anti-particle changes from repulsive to attractive,
- $\tau_0(t) = -2$, which represents the expansion value for which the interaction force between a macro vacancy and a macro interstitial changes from repulsive to attractive,
- $\tau_0(t) = -3/2$, which corresponds to the passage from *the stage of inflation*, during which

the speed $\phi_U\left(\tau_0(t)\right)$ of expansion decreases, to *the stage of expansion* during which the speed $\phi_U\left(\tau_0(t)\right)$ of expansion begins to increase again,

• $\tau_0(t)=-1$, which corresponds to the transition from the repulsion stage between macroscopic vacancies to the attraction stage between macroscopic vacancies,

• $\tau_0(t)=1$, which represents the expansion value from which the macroscopic vacancies become black holes,

• $\tau_0(t)=\tau_{0cr}$, which represents *the critical expansion* from which longitudinal waves appear within the lattice to the detriment of localized eigen modes of vibration of the expansion, and which also represents the critical expansion for which several of the gravitational interaction forces change sign, either by passing through an infinite singularity, or by passing through a zero value.

Beyond τ_{0cr}, the cosmological evolution of the lattice passes from *the stage of expansion*, during which the speed $\phi_U\left(\tau_0(t)\right)$ of expansion is positive, to *a stage of contraction* during which the speed $\phi_U\left(\tau_0(t)\right)$ of expansion becomes negative, and which ends after *stages of contraction and deflation,* by a *"big-crunch"* followed by *a new "big-bang"* of the lattice, therefore by *a "big-bounce"* of the lattice due to the kinetic energy stored, as well show figures 3.7 and 3.10.

A plausible scenario of cosmological evolution of topological singularities in a perfect cosmological lattice

On the basis of figure 10.2, a plausible scenario of evolution of the topological singularities of the cosmological lattice can then be imagined, which implies several distinct stages to arrive at the current state of our Universe:

(1) Hypothetical liquefaction and solidification of the lattice during the "big-bounce" and formation of an "initial hot soup" of loops of singularities.

In the scenario of a "big-bounce" Universe represented in figures 3.7 and 3.10, the intense contraction of the lattice at the end of the "big-crunch" must certainly heat the lattice to an extreme since its compression becomes gigantic, which could lead to to its "liquefaction". It is obvious that such a phenomenon, modeled on our knowledge of usual matter, is not easy to imagine, and presupposes that the cells of the lattice are associated with "strange particles", which would be responsible for the mass associated with lattice (and which would perhaps correspond to the famous Higgs particles of the Standard Model). For the lattice to effectively present a phase transition phenomenon by "liquefaction", its complete state function should not only contain the terms of free energy for deformation, but also thermal terms leading to the phase transition .

Assuming therefore that the *"big-bang"* following the *"big-crunch"* occurs from a very hot liquid of massive "strange particles", the inflation phase of cosmological evolution should lead to a cooling of the liquid (to a decrease in its thermal agitation) and to a sudden *"solidification"* of the liquid in the form of the perfect cosmological lattice which we introduced in chapter 3. During this phase transition, it could then appear *structural defects of the lattice*, in the form of dislocations, disclinations, loops, vacancies and interstitials, and even grain boundaries, very similar to what happens for example during the rapid solidification of a metal .

We could speak of *an "initial hot soup" of singularity loops*, the term soup including the fact of a homogeneous initial distribution of the various types of singularity loops and a very great mobility of these loops as in a liquid, then that the term hot includes the notion of a still extremely hot lattice, in other words containing a very large quantity of *transverse wave modes (photons)* and *localized longitudinal vibration modes (gravitons)*, implying *a very strong thermal agitation of the initial loops*.

(2) Inflation of the lattice and condensation of the loops of singularities into particles and anti-particles.

During the inflation of the cosmological lattice, and therefore of its cooling, and as soon as the temperature has dropped sufficiently, the various dislocation and disclination loops will regroup within the "hot soup" to form complex and localized topological dispirations, formed by dislocation and disclination loops linked by the weak interaction force (chapter 9), and corresponding to the various elementary particles of matter (électron e^-, neutrino ν^0, neutron n^0, proton p^+, etc.) and of anti-matter (positron $\overline{e}^+$, anti-neutrino $\overline{\nu}^0$, anti-neutron $\overline{n}^0$, anti-proton $\overline{p}^-$, etc.) of our Universe. The existence of such combinations of loops in localized form, which can correspond to the various elementary particles of our Universe, will be discussed in chapter 13 in this work.

(3) Formation of galaxies by precipitation of matter and anti-matter in a sea of repulsive neutrinos.

In the hot soup of lattice singularities, an initially homogeneous mixture of particles and anti-particles, there are particles and anti-particles whose gravitational interaction is attractive (electron e^-, neutron n^0, proton p^+, positron $\overline{e}^+$, anti-neutrino $\overline{\nu}^0$, anti-neutron $\overline{n}^0$, anti-proton $\overline{p}^-$, etc.), but there are also the various neutrinos ν^0 whose gravitational interaction with other particles (such as electron e^-, neutron n^0, proton p^+, positron $\overline{e}^+$, anti-neutron $\overline{n}^0$, anti-proton $\overline{p}^-$, etc.) is repulsive, or almost non-existent (with anti-neutrinos $\overline{\nu}^0$), and there is obviously also a sea of energetic photons interacting strongly with particles and anti-particles charged via the Compton scattering mechanism. This situation linked to the component of the edge dislocation loops with their curvature charge is completely original in our approach, and will necessarily lead to explain the phenomenon of *initial formation of galaxies*, which is very difficult to explain at present by other theories.

Indeed, it is possible to make an extremely simplified model of the initial and homogeneous hot soup of particles and anti-particles to describe the formation of galaxies. Consider that the initial hot soup forms a kind of liquid composed of attractive particles on the one hand (electron e^-, neutron n^0, proton p^+, positron $\overline{e}^+$, anti-neutrino $\overline{\nu}^0$, anti-neutron $\overline{n}^0$, anti-proton $\overline{p}^-$, etc.) and repulsive neutrinos ν^0 on the other part (electronic neutrino ν_e, muonic neutrino ν_μ and tau neutrino ν_τ), and let us try to express the free interaction energy $f^{interaction}$ per particle within this liquid mixture. By introducing the concentrations C_{ν^0} nd $C_X = 1 - C_{\nu^0}$ of repulsive neutrinos ν^0 and attractive particles X into the mixture, the free energy of interaction can be written as the sum of an internal energy interaction term and an entropic mixing term[1], as shown in the first formula in figure 10.3, where z is the mean coordination number, which represents

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[1] *see section 7.6 in «Théorie eulérienne des milieux déformables: charges de dislocation et de désinclinaison dans les solides», G. Gremaud, Presses Polytechniques et Universitaires Romandes, Lausanne 2013, ISBN 978-2-88074-964-4 (751 pages).*

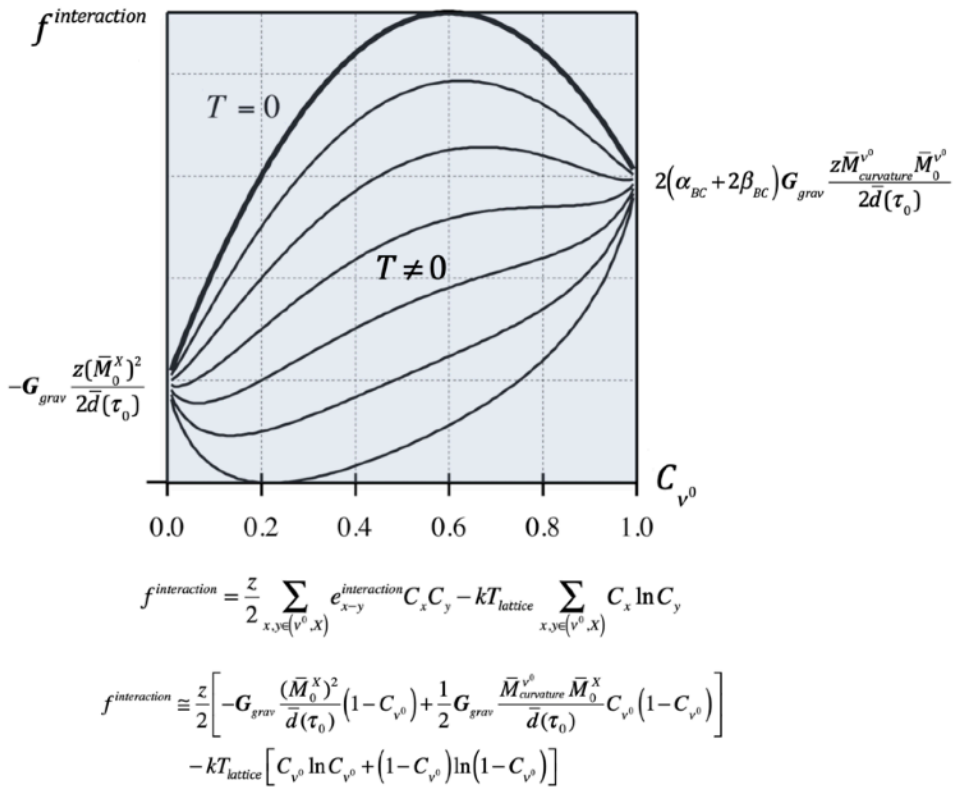

Figure 10.3 *- The particle free interaction energy within the initial hot soup of particles as a function of the concentration C_{ν^0} of repulsive neutrinos and for different lattice temperatures*

the mean number of neighboring particles with which a particle can form a pair interaction and where the factor 1/2 is introduced so as not to count each interaction twice.

By then introducing an average value of the mass of inertia of the attractive particles $\bar{M}^{X}_{0} > 0$ and neutrinos $\bar{M}^{\nu^0}_{0} > 0$, as well as the average mass of curvature $\bar{M}^{\nu^0}_{courbure} < 0$ of the matter neutrinos, and by supposing an average distance $\bar{d}(\tau_0)$ between the particles in the initial homogeneous hot soup, one can express very approximately the free energy of interaction per particle in the form of the second relation of figure 10.3. If we represent this interaction free energy as a function of the neutrino concentration C_{ν^0} for different lattice temperatures, as in the diagram in figure 10.3, we see that at high temperature the minimum free energy is obtained by a homogeneous mixture of attractive particles X and repulsive neutrinos ν^0. But if the lattice temperature drops sufficiently, there appear two minima of free energy depending on the concentration C_{ν^0} : a minimum corresponding to a very low concentration of neutrinos and a minimum corresponding to a very high concentration of neutrinos. In fact, there appears *a phase transition by precipitation*, which tends to separate the attractive particles X and the repulsive neutrinos ν^0, as represented in figure 10.4 (a). It will therefore appear *precipitates*, a kind of islands made up of attractive particles X, within a sea of repulsive neutrinos ν^0. At low temperatures, the minimum free energy corresponds to the concentrations $C_{\nu^0} = 0$ and $C_{\nu^0} = 1$, which corresponds to a complete separation of the attractive particles and the repellent neutrinos.

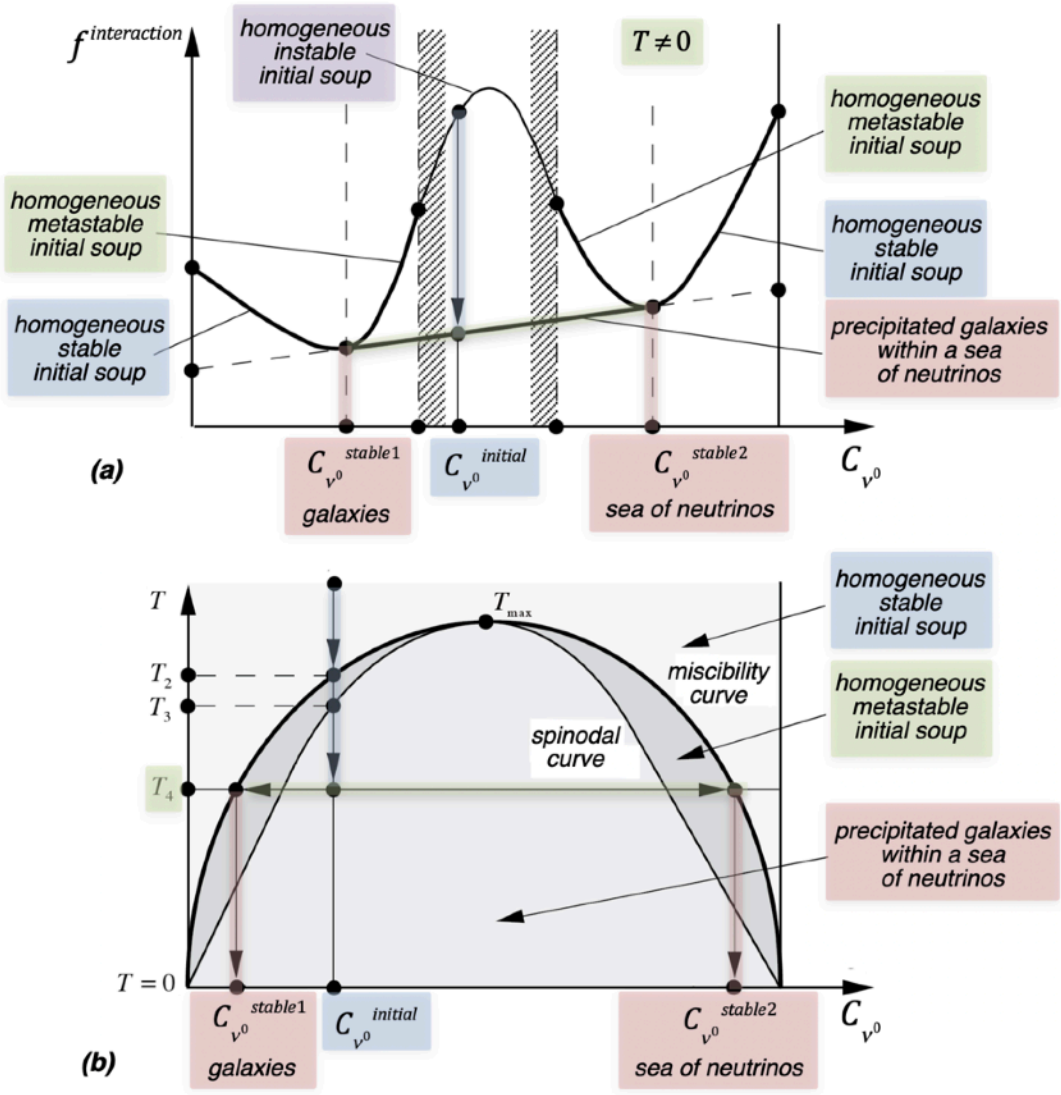

***Figure 10.4 - (a)** Precipitation of the galaxies within the initial hot soup of concentration $C_{\nu^0}^{initial}$ of neutrinos at a given temperature,*
***(b)** phase diagram of matter in the Universe as a function of temperature*

The *phase transition by precipitation* of attractive particles and anti-particles in the form of localized clusters can be represented by *a precipitation phase diagram* as in Figure 10.4 (b), and it corresponds perfectly to the phenomenon of *galaxy formation in our Universe* . In this model, it is the existence of repulsive neutrinos that becomes the engine of galaxy formation. And it is very interesting to note that the repulsion of neutrinos of matter is due exclusively to the charge of curvature of neutrinos, a concept which does not exist in General Relativity nor in the Standard Model of elementary particles. On the other hand, we already know that the curvature charge is also at the origin of the weak asymmetry existing between matter and anti-matter, which confirms the strong link existing between this asymmetry observed experimentally and the initial formation of galaxies and structures of our current Universe.

(4) Formation and segregation of matter and anti-matter within galaxies.

Now let's take a look at what's going on in emerging galaxies, during the precipitation of

particles and anti-particles that attract each other. Within this precipitating liquid phase of particles, the attractive gravitational interaction forces have small differences depending on whether we are dealing with particles or anti-particles. Consider for example the family of particles X and anti-particles $\overline{X}$. The gravitational interaction forces between these particles are expressed in figure 10.1. With the mass of inertia M_0^X of these particles, we deduce, thanks to the classical Newton equation, the acceleration that these particles undergo during their various interactions X - X , X - $\overline{X}$ and $\overline{X}$ - $\overline{X}$: $\boldsymbol{a}_{grav}^{X-X} \cong \boldsymbol{G}_{grav}\left(\boldsymbol{M}_0^X - \boldsymbol{M}_{courbure}^{\overline{X}}\right)/d^2$, $\boldsymbol{a}_{grav}^{X-\overline{X}} \cong \boldsymbol{G}_{grav}\boldsymbol{M}_0^X/d^2$ and $\boldsymbol{a}_{grav}^{\overline{X}-\overline{X}} \cong \boldsymbol{G}_{grav}\left(\boldsymbol{M}_0^X + \boldsymbol{M}_{courbure}^{\overline{X}}\right)/d^2$. We deduce that $\boldsymbol{a}_{grav}^{X-X} < \boldsymbol{a}_{grav}^{X-\overline{X}} < \boldsymbol{a}_{grav}^{\overline{X}-\overline{X}}$, therefore anti-particles $\overline{X}$ attract more strongly than particles X , and we must therefore see a *phenomenon of progressive segregation of anti-particles and particles* appear, during which anti-particles will tend to regroup towards the center of the emerging galaxy, leaving the particles in the periphery of the galaxy.

It is clear that this phenomenon of segregation must be accompanied by an intense activity of annihilation between particles and anti-particles, in an area located around the center of the galaxy, and which should necessarily be a source of intense gamma radiation. But there must also appear an activity of combinations between particles and between anti-particles to form matter and anti-matter (initially hydrogen and anti-hydrogen atoms and helium andanti-helium atoms). These annihilation and recombination processes must continue until there appears to be an effective separation between a galaxy core composed essentially of anti-matter and a galaxy periphery composed essentially of matter. We note again that this process of segregation of matter and anti-matter is to be associated with the charge of curvature of the dislocation edge loops, which is an exclusive property of our approach, since it is these charges which are responsible of the equivalent mass of curvature, itself responsible for the small difference in attractive gravitational interaction between matter and anti-matter.

(5) Formation of a cosmic radiation background.

Initially, all particles and anti-particles are in thermal equilibrium with a sea of photons, via interactions by Compton scattering, and as long as their temperature has not dropped enough to form atoms. But as soon as the temperature drops below around 3,000 K, helium, anti-helium, hydrogen and anti-hydrogen atoms are formed which ensures the electrical neutrality of matter and anti-matter. At this time there is also decoupling of photons from neutral matter and anti-matter. The Universe therefore becomes transparent to photons, which then fill all the space in the form of *a cosmic microwave background*. This cosmic radiation background has been observed and studied experimentally: it is almost *isotropic* and presents *the spectrum of a perfect black body*, that is to say *a Planck distribution of the energy density* $U(\nu)$ *of photons*, centered on a temperature T which is currently measured at 2.7 K (figure 10.5, with c the speed of light, h the Planck constant, k the Boltzmann constant, T the temperature of the black body and ν the photon frequency). We will come back to the process that leads to the "cooling" of this cosmic microwave background.

(6) Gravitational collapse and disappearance of anti-matter by the formation of gigantic black holes in the center of galaxies.

The formation by precipitation of galaxies composed of attractive particles and anti-particles within the sea of repulsive neutrinos will lead to enormous pressures in the heart of galaxies as they evolve. The appearance of a spinning movement of the galaxies makes it possible to

partially balance the gravitational pulling forces within the galaxies and the compressive forces of the neutrino sea. But at the very center of galaxies, the compressive forces could reach values sufficient to witness a gravitational collapse of their hearts. If such a collapse occurs, as the heart of the galaxies is formed essentially of anti-matter, it will be responsible for the appearance of macroscopic vacancies since during the collapse the loops of twist disclinations will annihilate (if the anti-matter was initially electrically neutral), while the vacancy edge dislocations loops specific to anti-matter combine to form macroscopic lattice vacancies in the center of the galaxies.

The macroscopic vacancy created in the center of a galaxy by the gravitational collapse of anti-matter is in fact nothing but *a gigantic topological singularity*, which becomes *a huge black hole* as soon as the bottom expansion of the lattice exceeds unity ($\tau_0 \geq 1$). This phenomenon of gravitational collapse of segregated anti-matter in the heart of galaxies would then explain perfectly, and quite simply, experimental observations of *the existence of gigantic black holes in the center of most galaxies* and of *the disappearance of the anti-matter in our current universe*.

(7) Coalescence of matter in galaxies and formation of stars.

The matter that composes the galaxies after the collapse of the anti-matter core in a central black hole will gradually coalesce under the effect of the gravitational attraction to form clouds of hydrogen and helium gases, various types of stars and planetary systems, such as those observed in our current universe.

(8) Gravitational collapse of stars and formation of neutron stars.

As the galaxies are then essentially made up of matter, based on *edge dislocation loops of interstitial nature*, any gravitational collapse of a very large star under the effect of its own gravity must lead to *a localized topological singularity of a macroscopic interstitial type*, and not of the macroscopic vacancy type. Consequently, *there cannot appear vacancy type black holes after the gravitational collapse of a massive star composed of matter*.

Experimentally, we sometimes and suddenly observe this phenomenon of gravitational collapse of massive stars of matter in the form of *a supernova* (a cloud of residual gases from the initial explosion of the star, which extends to very high speed), with, in the center of the supernova, a relatively small and very massive object, which should correspond to a residual macroscopic interstitial singularity, which we commonly describe as *pulsar* (by its properties of emission of electromagnetic pulses whose frequency corresponds to the very fast frequency of rotation of the object on itself) or as *neutron star* (due to the enormous mass density of the object).

The rest of the story is then well known and well described by astrophysicists, with the formation of atoms of increasing mass by the nuclear fusion of hydrogen and light elements in the heart of stars and by the dispersion of these elements by the supernovae, ultimately leading to the appearance of all the elements of Mendeleev's table and the formation of increasingly complex stars, planetary systems, etc.

(9) The future of our universe.

In the scenario of *the "big-bounce" universe* represented in figures 3.7 and 3.10, which in fact corresponds best to our own universe, the phase of expansion at increasing speed, under conditions where there is no propagation of longitudinal waves, is between the values $\tau_0 = -3/2$ and $\tau_0 = \tau_{0cr} >> 1$. Our present Universe must therefore be situated in this field

of fundamental expansion since recent observations have shown that the expansion of the universe is most likely taking place at increasing speed. We can even say that the current background expansion should in fact be understood in the domain $1 < \tau_0 < \tau_{0cr}$, since massive black holes seem to have been observed in the center of most galaxies, especially in the center of our galaxy, the Milky Way.

Since this expansion range ($1 < \tau_0 < \tau_{0cr} >> 1$) is very large, it is difficult to know where our Universe is currently located and how long it will take for it to reach the critical expansion τ_{0cr}. But we can on the other hand affirm that when this one approaches the critical value τ_{0cr}, it will inevitably appear titanic phenomena of reshaping of celestial objects, matter, black holes and the sea of repulsive neutrinos since at that moment we will have essentially that:
- the gravitational constant G_{grav} *will become negative* by passing through a singularity at τ_{0cr},
- the eigen modes of localized vibrations will disappear in favor of the propagation of longitudinal waves, which should in fact correspond to *the disappearance of quantum physics* as we will see in the rest of this work.

These two phenomena alone should be cataclysmic. But one could still push further by considering the phenomena which should intervene during the phase of re-contraction of the cosmological lattice, especially during the reverse passage by the critical value τ_{0cr} where the gravitational constant would become positive again and where it would reappear eigen modes of localized vibrations instead of the propagation of longitudinal waves. These predictions are most likely in the realm of the possible with our approach, although certainly very difficult and very rough. In fact, we are swimming there in full science-prediction, not to say in full science-fiction.

The fact remains that our approach goes much further in explanations and predictions than general relativity, and that a number of exotic phenomena such as instantaneous displacement in space and time via the famous wormholes described from general relativity, which are the delight of theoretical physicists and science fiction writers, should be nothing but pure ranting in the light of our approach.

About the famous «dark matter» of astrophysicists

The formation of a *“sea of repelling neutrinos”* in which the galaxies are bathed perfectly explains the phenomenon attributed to *“dark matter”* by astrophysicists. Indeed, when we observe a galaxy and we measure experimentally the speeds of the stars composing it as a function of their distance from the center of the galaxy, we find that the speeds of the stars located on the periphery of the galaxy are too high compared to the speeds calculated by applying Newton's law of gravitation with the mass density of the stars (which can be measured experimentally by their brightness). Everything happens as if there was a halo of matter invisible to our eyes around the galaxy, which, by its gravitational effect, forces the stars to rotate faster to compensate for this attractive effect. This halo of invisible matter has been called *dark matter* by astrophysicists, and research into the very nature of this dark matter is currently one of the great subjects of basic research, having generated a plethora of diverse explanations, but none of which is satisfactory.

In our approach, the concept of dark matter is no longer necessary, because it is simply replaced by the concept of *"repulsive neutrino sea"* in which all the galaxies, globular clusters

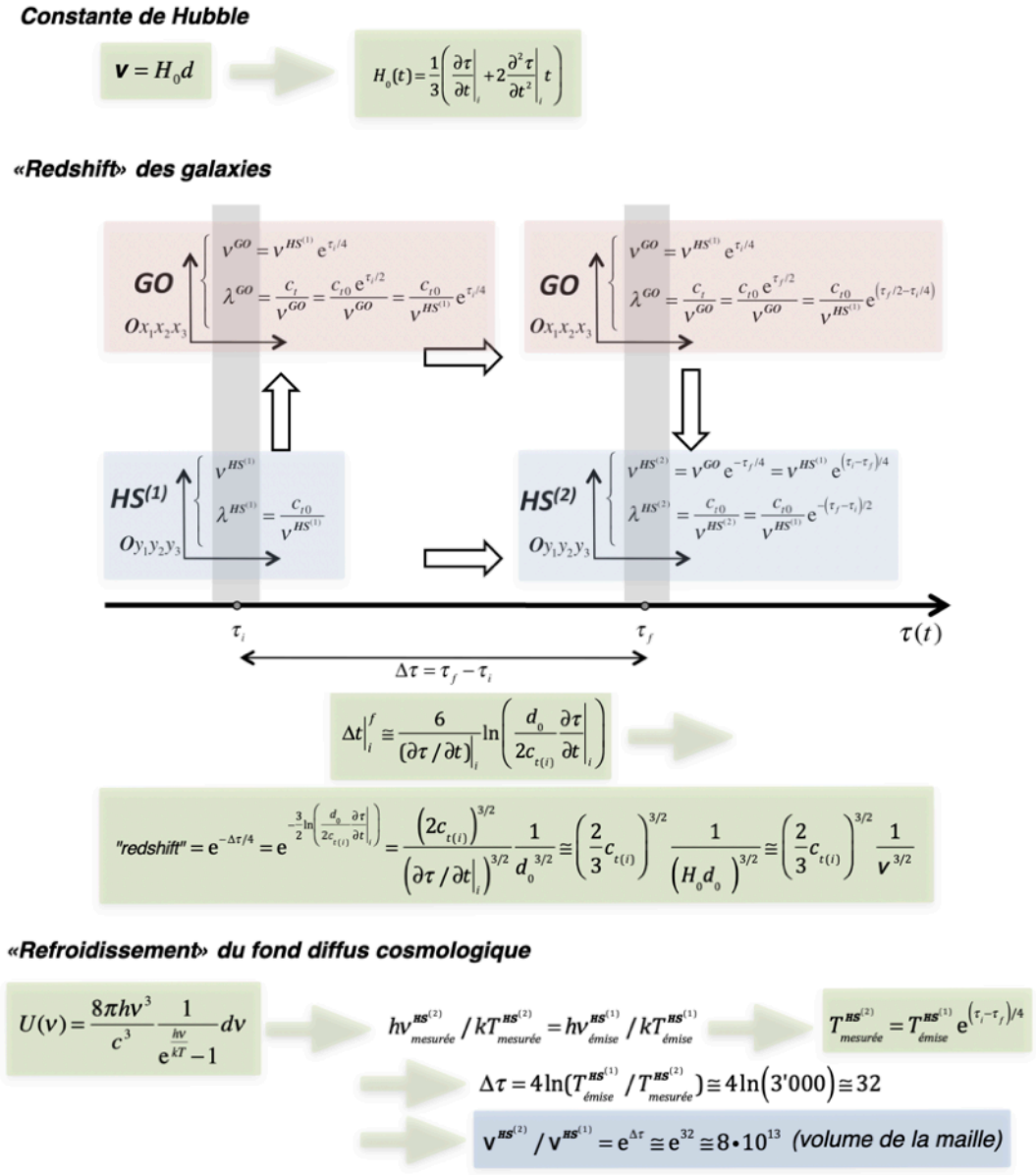

Figure 10.5 *- Constante de Hubble, «redshift» des galaxies et «refroidissement» du fond diffus cosmologique*

and other structures of the visible Universe bathe. Indeed, let us consider a galaxy subjected to the repulsive force of the sea of neutrinos in which it bathes. This repulsive force actually corresponds to a compressive force which is applied to stars in the suburbs of the galaxy. To resist this compressive force, the stars on the periphery of the galaxy must force to rotate faster than what is calculated on the basis of the visible mass, so as to balance the compressive force of the neutrino sea by an additional centripetal force of rotation.

About the Hubble's constant

Experimentally, we see that the light from galaxies has a redshift (redshift of the spectral lines of emission of atoms). This offset was attributed by Hubble to the apparent recession

speed $\boldsymbol{v}$ of the galaxies according to their distance d due to the expansion of the Universe, effect explained initially by the Doppler-Fizeau effect due to the flight movement of the galaxies in the space. The experimental relationship between the speed of recession and the distance d was measured by Hubble, who found that $\boldsymbol{v} = H_0 d$, where H_0 is *the Hubble constant* which is approximately 70 (km/s)/Mpc (70 km per second, per megaparsec). The initial interpretation of this observation as a Doppler-Fizeau effect due to the speed of separation of galaxies in space actually leads to galaxies which would be located at distances greater than 4,000 megaparsecs moving away from us at speeds higher than that of light, which is obviously nonsense from special relativity. The solution to this problem can be deduced from general relativity, for which the expansion of the universe should not be interpreted by a movement of galaxies in space, but rather by an inflation of space itself, which implies a progressive distancing of the objects which it contains (a little in the same way as in our approach where it is the perfect cosmological lattice which extends).

Let's take a look at the Hubble constant in our approach, which is very clearly distinguished from general relativity, by the existence of the scalar τ of volume expansion which is directly concerned by a cosmological expansion of the perfect cosmological lattice. Let us therefore suppose a cosmological evolution of the perfect cosmological lattice like that described in figures 3.7 and 3.10. In the course of evolution, suppose that the ***GO*** observes a certain region in graph 3.10, in which the cosmological lattice is expanding, and even expanding at increasing speed. Suppose that the ***GO*** observes galaxies that are initially distant from d_0 at the moment $t = 0$. If these galaxies *do not move in relation to the expanding cosmological lattice*, the initial distance d_0 will change over time, and the ***GO*** will observe that the distance between the two galaxies will increase exponentially as $d(t) = d_0 \exp\left[\left(\tau(t) - \tau_i\right)/3\right]$, so that the two galaxies will move away relative to each other with relative speed $\boldsymbol{v}(t) = \partial d(t)/\partial t$. The value of this speed can be approached by a second order development of the expansion $\tau(t)$ over time, which makes it possible to deduce the value $H_0 = \boldsymbol{v}/\boldsymbol{d}$ of the Hubble constant reported in figure 10.5. If the ***GO*** then measures this speed at an instant $t \neq 0$, it will find that the Hubble constant becomes dependent on the instant at which it observes the universe during its cosmological evolution, and in particular that this increases if one is in a domain where the speed of expansion of the universe increases.

About the «redshift» of galaxies

Now consider two galaxies that were initially distant from d_0 at the instant $t = 0$ for the ***GO***. If, at this instant $t = 0$, galaxy 1 emits a signal towards galaxy 2, the signal will travel a distance dx during the lapse of time dt such as $dx = c_t dt$. But as the lattice is expanding, and neglecting the acceleration of this expansion, we have that the speed of the transverse waves depends on the instant t, so that $c_t(t) = c_{t(i)} \exp\left[\left(\partial\tau/\partial t\right|_i) t/2\right]$, where $c_{t(i)}$ is the speed of the transverse waves at the instant $t = 0$. The distance d between the two galaxies will then be covered in the time lapse $\Delta t\Big|_i^f$ shown in figure 10.5, which can be calculated approximately thanks to the relationship giving $c_t(t)$.

When the signal is received by galaxy 2, the expansion of the universe will then have reached a value τ_f worth $\tau_f \cong \tau_i + \left(\partial\tau/\partial t\right)\Big|_i T$. Suppose that the signal emitted in galaxy 1 at the moment $t = 0$ is measured by a local observer ***HS*****(1)** at the frequency $\nu_{emitted}^{\boldsymbol{HS}^{(1)}}$ of a certain

spectral line of a given atom, the frequency $\nu_{received}^{\mathbf{HS}^{(2)}}$ of the signal received and measured by an observer ***HS(2)*** in galaxy 2 at the moment $t = T$ will be different because of the increase $\Delta\tau = \tau_f - \tau_i$ in expansion of the Universe during propagation. Thus, an observer ***HS(2)*** located in galaxy 2 will be able to compare the frequency $\nu_{received}^{\mathbf{HS}^{(2)}}$ of this signal received with the frequency $\nu_{émise}^{\mathbf{HS}^{(2)}}$ of the same spectral line of the same atom emitted in his own laboratory, and he will call *"redshift" of galaxy 1* the ratio between these two frequencies: $redshift = \nu_{received}^{\mathbf{HS}^{(2)}} / \nu_{emitted}^{\mathbf{HS}^{(2)}}$. To calculate this redshift, we must schematically represent how the physical values measured by the observer ***HS(1)*** in galaxy 1 at the instant $t = 0$ with the same physical values measured by the ***GO*** at the instant $t = 0$ and at the instant $t = T$ as well as by the observer ***HS(2)*** in galaxy 2 at the moment $t = T$. For this, we remember that the time spans Δt_y measured by an ***HS*** in its own reference frame $\boldsymbol{O}y_1y_2y_3$ are perceived by the ***GO*** in its local reference frame $\boldsymbol{O}x_1x_2x_3$ as time spans Δt linked by the expression $\Delta t_y^{\mathbf{HS}} = \Delta t^{\mathbf{GO}}\, \mathrm{e}^{\tau/4}$ in which τ is the expansion of the lattice at the location where is ***HS***. This expression also makes it possible to link also the frequency measurements made by an ***HS*** and by the ***GO*** in the form $\nu_y^{\mathbf{HS}} = \nu^{\mathbf{GO}}\, \mathrm{e}^{-\tau/4}$. With this relation, we can schematically represent in figure 10.5 how the frequency and wavelength measurements made during the signal transmission experiment between galaxies 1 and 2 behave.

We then observe that the "redshift" measured by the observe ***HS(2)*** is very simply related to the expansion increase $\Delta\tau = \tau_f - \tau_i$ of the Universe that occurred during the propagation since $\textit{"redshift"} = \nu_{emitted}^{\mathbf{HS}^{(1)}}\, \mathrm{e}^{(\tau_i - \tau_f)/4} / \nu_{emitted}^{\mathbf{HS}^{(2)}} = \mathrm{e}^{-\Delta\tau/4}$. By calculating the value of $\Delta\tau$ thanks to the expression of the lapse of time Δt_i^f used by the light to traverse the distance separating the two galaxies, one obtains the expression reported in figure 10.5 for the “redshift” measured by the observer ***HS(2)***, which depends on both the instantaneous speed of expansion $\partial\tau / \partial t\big|_i$ and the initial distance d_0 between the two galaxies. But we can also connect the “redshift” to the instantaneous Hubble constant H_0 or to the relative speed $\boldsymbol{v}$ of recession of the galaxies as reported in figure 10.5.

The "redshift" observed by the observer ***HS(2)*** will therefore be proportional to $1/d_0^{3/2}$ what means that the frequency ratio decreases if the initial distance d_0 between the galaxies increases, and therefore that the "red shift" of the spectral line increases with the increase in the initial distance d_0. The "redshift" is also proportional to $1/\left(H_0\right)^{3/2}$, which means that it decreases if the Hubble constant increases. And finally it is also proportional to $1/\boldsymbol{v}^{3/2}$. However, the velocity of reciprocal remoteness of two galaxies is not limited by the speed of transverse waves in our approach since this speed is associated with *the speed of the lattice in the absolute space of the* ***GO***, which satisfies a purely Newtonian dynamic. Thus, the measured "redshift" can tend towards 0 if the recession speed $\boldsymbol{v}$ of expansion tends to infinity.

Note again that these calculations were made by making two restrictive assumptions:

- that we are in a limited region in graph 3.10 in which the cosmological lattice is expanding, and which can be approached by a second order development in time of expansion $\tau(t)$. For phenomena which would spread over much longer times, the calculations would be particularly complicated since it would then be necessary to know exactly the function of the cosmological expansion $\tau(t)$ of the lattice.
- that the galaxies *do not move in relation to the expanding cosmological lattice*. If this were not the case, for example because of the gravitational interactions between the galaxies, it would be

necessary to add to the "redshift" due to the expansion of the lattice a Doppler-Fizeau effect *due to the displacements of the galaxies compared to the lattice*, such than that described in figure 6.12.

About the «cooling» mechanism of the cosmic microwave background

The cosmic microwave background is currently observed as *a perfect black body spectrum*, very precisely following *the Planck distribution of the energy density* $U(\nu)$ *of photons* (figure 10.5), centered on a temperature T of 2.7 K. We assume that this radiation is fossil from the big bang, which formed during the decoupling of photons from particles during the formation of neutral atoms of helium and hydrogen, and that, therefore, it was originally emitted with a temperature of the order of 3'000 K. We can then ask ourselves what is the "cooling" mechanism of this radiation in the light of our approach. To do this, just look at figure 10.5. If we assume that the photon-matter decoupling occurred when the Universe had an expansion τ_i and that the current expansion of the Universe is τ_f, the emission frequency of the microwave background is given by $\nu_{émise}^{HS^{(1)}}$ and the frequency currently observed by an observer ***HS*$^{(2)}$** is worth $\nu_{measured}^{HS^{(2)}} = \nu_{emitted}^{HS^{(1)}} \mathrm{e}^{(\tau_i - \tau_f)/4}$. From Planck's distribution (figure 10.5), there is the following relationship $h\nu_{measured}^{HS^{(2)}} / kT_{measured}^{HS^{(2)}} = h\nu_{emitted}^{HS^{(1)}} / kT_{emitted}^{HS^{(1)}}$ between the frequency of black body radiation and its color temperature, measured at the expansions τ_f and τ_i. We therefore deduce that $T_{measured}^{HS^{(2)}} = T_{emitted}^{HS^{(1)}} \mathrm{e}^{-\Delta\tau/4}$, so that a numerical value of the variation in the expansion of the lattice between the moment of photon-matter decoupling and the current time can be calculated as $\Delta\tau = 4\ln(T_{emitted}^{HS^{(1)}} / T_{measured}^{HS^{(2)}}) \cong 4\ln(3'000) \cong 32$. This increase in expansion corresponds in fact to *an increase in the volume* $\mathbf{v}$ *of the elementary cell of the lattice* worth approximately $\mathbf{v}^{HS^{(2)}} / \mathbf{v}^{HS^{(1)}} = \mathrm{e}^{\Delta\tau} \cong \mathrm{e}^{32} \cong 8 \cdot 10^{13}$, which must certainly take place during the inflation phase of the cosmological lattice (figure 3.10).

We therefore see that the apparent "cooling" of the cosmic microwave background is a direct effect of the expansion of the lattice, which dramatically changes the rulers and clocks of local reference frames $\boldsymbol{O}y_1y_2y_3$.

It is also interesting to note that, for the ***GO***, the frequency $\nu_{measured}^{GO}$ of the cosmic microwave background does not change during the expansion since it is always worth the same value as at the time of its emission $\nu_{measured}^{GO} = \nu_{emitted}^{HS^{(1)}} \mathrm{e}^{\tau_i/4}$. But on the other hand, for the ***GO***, it is the wavelength $\lambda_{measured}^{GO}$ which will change with the expansion, since this is then equal to $\lambda_{measured}^{GO} = c_t / \nu_{measured}^{GO} = c_{t0} \mathrm{e}^{\tau(t)/2} / \nu_{measured}^{GO} = c_{t0} \mathrm{e}^{\tau(t)/2 - \tau_i/4} / \nu_{emitted}^{HS^{(1)}}$. The points of view of the local observers ***HS*$^{(i)}$** and of the external observer ***GO*** are therefore very different, and this is due to the fact that the speed of the transverse waves of rotation (speed of light) is a universal constant always valid for the observers ***HS*$^{(i)}$** whatever the state of expansion of the lattice in which they are placed, while the celerity of the transverse waves of rotation varies enormously according to the instantaneous expansion of the lattice for the external observer ***GO***.