VIII - ON THE ORIGIN OF COSMOLOGICAL EVOLUTION AND « DARK MATTER » IN A LATTICE UNIVERSE

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Extract from pages 491 to 502 of chapter 27 of the book « Universe and Matter conjectured as a 3-dimensional Lattice with Topological Singularities », Amazon, Charleston (USA) 2016, 650 pages, ISBN 978-2-8399-1934-0 (http://gerardgremaud.ch/) .

In a lattice universe, it is possible to imagine a scenario of cosmological evolution of the topological singularities which form after the big-bang. This scenario explains the formation of galaxies, the phenomenon of *dark matter* of the astro-physicists, the disappearance of anti-matter from the Universe, the formation of massive black holes in the center of galaxies of matter, the formation of stars and the formation of neutron stars during the gravitational collapse of matter.

On matter and anti-matter, and their gravitational interactions

Starting from a conjecture stipulating that the singularities of vacancy nature correspond by analogy to anti-matter and the singularities of interstitial nature to matter, we introduce the following hypothesis:

- the particles of matter (electron e^-, neutrino ν^0, neutron n^0, proton p^+, etc.) of the Universe are made of twist disclination loops, which confer them an electrical charge, of mixed dislocation loops, which give them a dipolar electric charge, and of edge dislocation loops of interstitial nature, which gives 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 are made of twist disclination loops, which give them an electrical charge, of mixed dislocation loops, which give them a dipolar moment, and of edge dislocation loops of vacancy type which gives them a *positive curvature charge*.

On the asymmetry between particles and anti-particles

If we accept this distinction between particles and anti-particles, the existence of a positive or a negative charge of curvature, due to whether the edge loop is of interstitial or vacancy type, does not appear in General Relativity, nor in the Standard Model. This introduces a weak asymmetry between particles and anti-particles which only exists in our theory.

This asymmetry is similar to the asymmetry observed experimentally between particles and anti-particles in particle physics, but which has no explanation. This asymmetry is seen in certain properties of fundamental particles (like the violation of ***CP*** symmetry, an action combined of a charge conjugation ***C*** and a reflexion symmetry ***P***), but not the rest mass of these particles (linked to the non-violation of the ***CPT*** symmetry, an action combined of a charge conjugation ***C***, a reflexion symmetry ***P*** and a time inversion ***T***)! However, in modern physics, be it the Standard Model or General Relativity, the notion of charge of curvature doesn't exist as it only appears due to the presence of topological defects of the lattice as developed in this work! This property of curvature charge which is linked to the topological singularities could therefore be a great candidate to explain the experimentally observed asymmetry between particles and anti-particles. To simplify let's call:

- *particle* X a matter particle like an electron e^-, a muon μ^-, a tau τ^-, a neutrino n^0, a proton p^+ (or any other elementary particle composed of quarks) which involves twist loops, with electrical charges, eventually mixed loops in the case of a dipolar electrical field and a majority of edge loops of interstitial nature, and thus *a negative curvature charge*,

- *anti-particle* $\bar{X}$ an anti-matter particle like a positron $\bar{e}^+$, an anti-muon $\bar{\mu}^+$, an anti-tau $\bar{\tau}^+$, an anti-neutron $\bar{n}^0$, an anti-proton $\bar{p}^-$ (or any other particle made of quarks) which involves twist loops and their electrical charges, eventually mixed loops in the case of a dipolar electric field and a majority of edge loops of vacancy nature and thus *a positive curvature charge*,

- *neutrino* ν^0 a particle of matter corresponding to the electronic neutrino ν_e, to the muonic neutrino ν_μ or to the tau neutrino ν_τ, which contains no twist loops and no mixed loops, but only edge loops of interstitial nature and therefore a *negative curvature charge*,

- *anti-neutrino* $\bar{\nu}^0$ a particle of anti-matter corresponding to the electronic anti-neutrino $\bar{\nu}_e$, the muon anti-neutrino $\bar{\nu}_\mu$ or the tau anti-neutrino $\bar{\nu}_\tau$, which contains no twist loops, no mixed loops but only edge loops of vacancy type, and thus a *positive curvature charge*.

To these 4 types of particles or anti-particles, we can, thanks to the previous chapters, assign inertial masses and equivalent masses of curvature, which satisfy the following relations in the case of particles and anti-particles and in the case of neutrinos and anti-neutrinos

$$\begin{cases} M_0^X = M_0^{\bar{X}} > 0 \\ M_{curvature}^{\bar{X}} > 0 \quad ; \quad M_{curvature}^{X} < 0 \\ \left| M_{curvature}^{X} \right| = M_{curvature}^{\bar{X}} << M_0^X = M_0^{\bar{X}} \end{cases} \tag{27.1}$$

$$\begin{cases} M_0^{\nu^0} = M_0^{\bar{\nu}^0} > 0 \\ M_{curvature}^{\bar{\nu}^0} > 0 \quad ; \quad M_{curvature}^{\nu^0} < 0 \\ \left| M_{curvature}^{\nu^0} \right| = M_{curvature}^{\bar{\nu}^0} >> M_0^{\nu^0} = M_0^{\bar{\nu}^0} \end{cases} \tag{27.2}$$

On the effect of the asymmetry between particles and anti-particles on the gravitational interactions

Thus, without knowing a-priori the exact composition of the various particles in terms of singular loops, we can deduce thanks to these relationships between mass of inertia and mass of curvature, relevant informations with regard to the behavior of the forces of gravitational interaction between the diverse particles. Indeed, in the case of the interactions between particles X and $\bar{X}$, we have, thanks to table 25.1, that

$$\begin{cases} \boldsymbol{F}_{grav}^{X-X} \cong \boldsymbol{G}_{grav} \dfrac{\left(M_0^X\right)^2}{d^2} + \boldsymbol{G}_{grav} \dfrac{M_{curvature}^X M_0^X}{d^2} \cong \boldsymbol{G}_{grav} \dfrac{\left(M_0^X\right)^2}{d^2} - \boldsymbol{G}_{grav} \dfrac{M_{curvature}^{\bar{X}} M_0^X}{d^2} \\ \boldsymbol{F}_{grav}^{X-\bar{X}} \cong \boldsymbol{G}_{grav} \dfrac{M_0^X M_0^{\bar{X}}}{d^2} + \dfrac{1}{2}\boldsymbol{G}_{grav} \dfrac{M_{curvature}^X M_0^{\bar{X}}}{d^2} + \dfrac{1}{2}\boldsymbol{G}_{grav} \dfrac{M_{curvature}^{\bar{X}} M_0^X}{d^2} \cong \boldsymbol{G}_{grav} \dfrac{\left(M_0^X\right)^2}{d^2} \\ \boldsymbol{F}_{grav}^{\bar{X}-\bar{X}} \cong \boldsymbol{G}_{grav} \dfrac{\left(M_0^{\bar{X}}\right)^2}{d^2} + \boldsymbol{G}_{grav} \dfrac{M_{curvature}^{\bar{X}} M_0^{\bar{X}}}{d^2} \cong \boldsymbol{G}_{grav} \dfrac{\left(M_0^X\right)^2}{d^2} + \boldsymbol{G}_{grav} \dfrac{M_{curvature}^{\bar{X}} M_0^{\bar{X}}}{d^2} \end{cases} \tag{27.3}$$

From which we deduce the following inequality relationships between the forces of gravitational interaction

$$\boldsymbol{F}_{grav}^{X-X} < \boldsymbol{F}_{grav}^{X-\bar{X}} < \boldsymbol{F}_{grav}^{\bar{X}-\bar{X}} \tag{27.4}$$

As $M_{curvature}^{\bar{X}} << M_0^{\bar{X}}$, the difference between the forces of interaction remain weak, but it assures us nonetheless that there is an asymmetry between particles and anti-particles (gravitationally the particles attract each other a little less than the anti-particles) which will play an important role in the 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

$$\left\{\begin{array}{l} \boldsymbol{F}_{grav}^{X-Y} \cong \boldsymbol{G}_{grav}\dfrac{M_0^X M_0^Y}{d^2} - \dfrac{1}{2}\boldsymbol{G}_{grav}\dfrac{M_{curvature}^{\bar{X}} M_0^Y}{d^2} - \dfrac{1}{2}\boldsymbol{G}_{grav}\dfrac{M_{curvature}^{\bar{Y}} M_0^X}{d^2} \\ \boldsymbol{F}_{grav}^{\bar{X}-Y} \cong \boldsymbol{G}_{grav}\dfrac{M_0^X M_0^Y}{d^2} + \dfrac{1}{2}\boldsymbol{G}_{grav}\dfrac{M_{curvature}^{\bar{X}} M_0^Y}{d^2} - \dfrac{1}{2}\boldsymbol{G}_{grav}\dfrac{M_{curvature}^{\bar{Y}} M_0^X}{d^2} \\ \boldsymbol{F}_{grav}^{X-\bar{Y}} \cong \boldsymbol{G}_{grav}\dfrac{M_0^X M_0^Y}{d^2} - \dfrac{1}{2}\boldsymbol{G}_{grav}\dfrac{M_{curvature}^{\bar{X}} M_0^Y}{d^2} + \dfrac{1}{2}\boldsymbol{G}_{grav}\dfrac{M_{curvature}^{\bar{Y}} M_0^X}{d^2} \\ \boldsymbol{F}_{grav}^{\bar{X}-\bar{Y}} \cong \boldsymbol{G}_{grav}\dfrac{M_0^X M_0^Y}{d^2} + \dfrac{1}{2}\boldsymbol{G}_{grav}\dfrac{M_{curvature}^{\bar{X}} M_0^Y}{d^2} + \dfrac{1}{2}\boldsymbol{G}_{grav}\dfrac{M_{curvature}^{\bar{Y}} M_0^X}{d^2} \end{array}\right. \tag{27.5}$$

From which we deduce the following inequality relations between the gravitational forces

$$\boldsymbol{F}_{grav}^{X-Y} < \boldsymbol{F}_{grav}^{\bar{X}-Y} \cong \boldsymbol{F}_{grav}^{X-\bar{Y}} < \boldsymbol{F}_{grav}^{\bar{X}-\bar{Y}} \tag{27.6}$$

These relations show again that particles attract each other a little less than anti-particles!

As regards neutrinos

$$\left\{\begin{array}{l} \boldsymbol{F}_{grav}^{\nu^0-\nu^0} \cong 2\left(\alpha_{BC}+2\beta_{BC}\right)\boldsymbol{G}_{grav}\dfrac{M_{curvature}^{\nu^0} M_0^{\nu^0}}{d^2} \cong -2\left(\alpha_{BC}+2\beta_{BC}\right)\boldsymbol{G}_{grav}\dfrac{M_{curvature}^{\bar{\nu}^0} M_0^{\nu^0}}{d^2} < 0 \\ \boldsymbol{F}_{grav}^{\nu^0-\bar{\nu}^0} \cong \left(\alpha_{BC}+2\beta_{BC}\right)\boldsymbol{G}_{grav}\dfrac{M_{curvature}^{\nu^0} M_0^{\bar{\nu}^0}}{d^2} + \left(\alpha_{BC}+2\beta_{BC}\right)\boldsymbol{G}_{grav}\dfrac{M_{curvature}^{\bar{\nu}^0} M_0^{\nu^0}}{d^2} + 2\left(\alpha_{BC}+2\beta_{BC}\right)\boldsymbol{G}_{grav}\dfrac{M_0^{\bar{\nu}^0} M_0^{\nu^0}}{d^2} \\ \qquad \cong 2\left(\alpha_{BC}+2\beta_{BC}\right)\boldsymbol{G}_{grav}\dfrac{\left(M_0^{\nu^0}\right)^2}{d^2} \\ \boldsymbol{F}_{grav}^{\bar{\nu}^0-\bar{\nu}^0} \cong 2\left(\alpha_{BC}+2\beta_{BC}\right)\boldsymbol{G}_{grav}\dfrac{M_{curvature}^{\bar{\nu}^0} M_0^{\bar{\nu}^0}}{d^2} \cong 2\left(\alpha_{BC}+2\beta_{BC}\right)\boldsymbol{G}_{grav}\dfrac{M_{curvature}^{\bar{\nu}^0} M_0^{\nu^0}}{d^2} > 0 \end{array}\right. \tag{27.7}$$

From which we deduce the following relations

$$\boldsymbol{F}_{grav}^{\nu^0-\nu^0} < 0 \quad ; \quad \boldsymbol{F}_{grav}^{\bar{\nu}^0-\bar{\nu}^0} > 0 \quad ; \quad \boldsymbol{F}_{grav}^{\nu^0-\bar{\nu}^0} \cong 0 \quad ; \quad \boldsymbol{F}_{grav}^{\nu^0-\nu^0} = -\boldsymbol{F}_{grav}^{\bar{\nu}^0-\bar{\nu}^0} \tag{27.8}$$

In other words, neutrinos repulse each other, with the same amplitude as the force with which anti-neutrinos attract each other. With regard to the interaction between neutrinos and anti-neutrinos, it is very weak as it involves $(M_0^{\nu^0})^2$!

Finally, with regards the interactions between particles and neutrinos, we have

$$\left\{\begin{array}{l} \boldsymbol{F}_{grav}^{X-\nu^0} \cong \boldsymbol{G}_{grav}\dfrac{M_0^X M_0^{\nu^0}}{d^2} - \dfrac{1}{2}\boldsymbol{G}_{grav}\dfrac{M_0^{\nu^0} M_{curvature}^{\bar{X}}}{d^2} - \dfrac{1}{2}\boldsymbol{G}_{grav}\dfrac{M_0^X M_{curvature}^{\bar{\nu}^0}}{d^2} \cong -\dfrac{1}{2}\boldsymbol{G}_{grav}\dfrac{M_0^{\nu^0} M_{curvature}^{\bar{X}}}{d^2} - \dfrac{1}{2}\boldsymbol{G}_{grav}\dfrac{M_0^X M_{curvature}^{\bar{\nu}^0}}{d^2} \\ \boldsymbol{F}_{grav}^{X-\bar{\nu}^0} \cong \boldsymbol{G}_{grav}\dfrac{M_0^X M_0^{\nu^0}}{d^2} - \dfrac{1}{2}\boldsymbol{G}_{grav}\dfrac{M_0^{\nu^0} M_{curvature}^{\bar{X}}}{d^2} + \dfrac{1}{2}\boldsymbol{G}_{grav}\dfrac{M_0^X M_{curvature}^{\bar{\nu}^0}}{d^2} \cong -\dfrac{1}{2}\boldsymbol{G}_{grav}\dfrac{M_0^{\nu^0} M_{curvature}^{\bar{X}}}{d^2} + \dfrac{1}{2}\boldsymbol{G}_{grav}\dfrac{M_0^X M_{curvature}^{\bar{\nu}^0}}{d^2} \\ \boldsymbol{F}_{grav}^{\bar{X}-\nu^0} \cong \boldsymbol{G}_{grav}\dfrac{M_0^X M_0^{\nu^0}}{d^2} + \dfrac{1}{2}\boldsymbol{G}_{grav}\dfrac{M_0^{\nu^0} M_{curvature}^{\bar{X}}}{d^2} - \dfrac{1}{2}\boldsymbol{G}_{grav}\dfrac{M_0^X M_{curvature}^{\bar{\nu}^0}}{d^2} \cong +\dfrac{1}{2}\boldsymbol{G}_{grav}\dfrac{M_0^{\nu^0} M_{curvature}^{\bar{X}}}{d^2} - \dfrac{1}{2}\boldsymbol{G}_{grav}\dfrac{M_0^X M_{curvature}^{\bar{\nu}^0}}{d^2} \\ \boldsymbol{F}_{grav}^{\bar{X}-\bar{\nu}^0} \cong \boldsymbol{G}_{grav}\dfrac{M_0^X M_0^{\nu^0}}{d^2} + \dfrac{1}{2}\boldsymbol{G}_{grav}\dfrac{M_0^{\nu^0} M_{curvature}^{\bar{X}}}{d^2} + \dfrac{1}{2}\boldsymbol{G}_{grav}\dfrac{M_0^X M_{curvature}^{\bar{\nu}^0}}{d^2} \cong +\dfrac{1}{2}\boldsymbol{G}_{grav}\dfrac{M_0^{\nu^0} M_{curvature}^{\bar{X}}}{d^2} + \dfrac{1}{2}\boldsymbol{G}_{grav}\dfrac{M_0^X M_{curvature}^{\bar{\nu}^0}}{d^2} \end{array}\right. \tag{27.9}$$

which implies that

$$\boldsymbol{F}_{grav}^{X-\nu^0}<0 \quad ; \quad \boldsymbol{F}_{grav}^{X-\bar{\nu}^0}\cong 0 \quad ; \quad \boldsymbol{F}_{grav}^{\bar{X}-\nu^0}\cong 0 \quad ; \quad \boldsymbol{F}_{grav}^{\bar{X}-\bar{\nu}^0}>0 \tag{27.10}$$

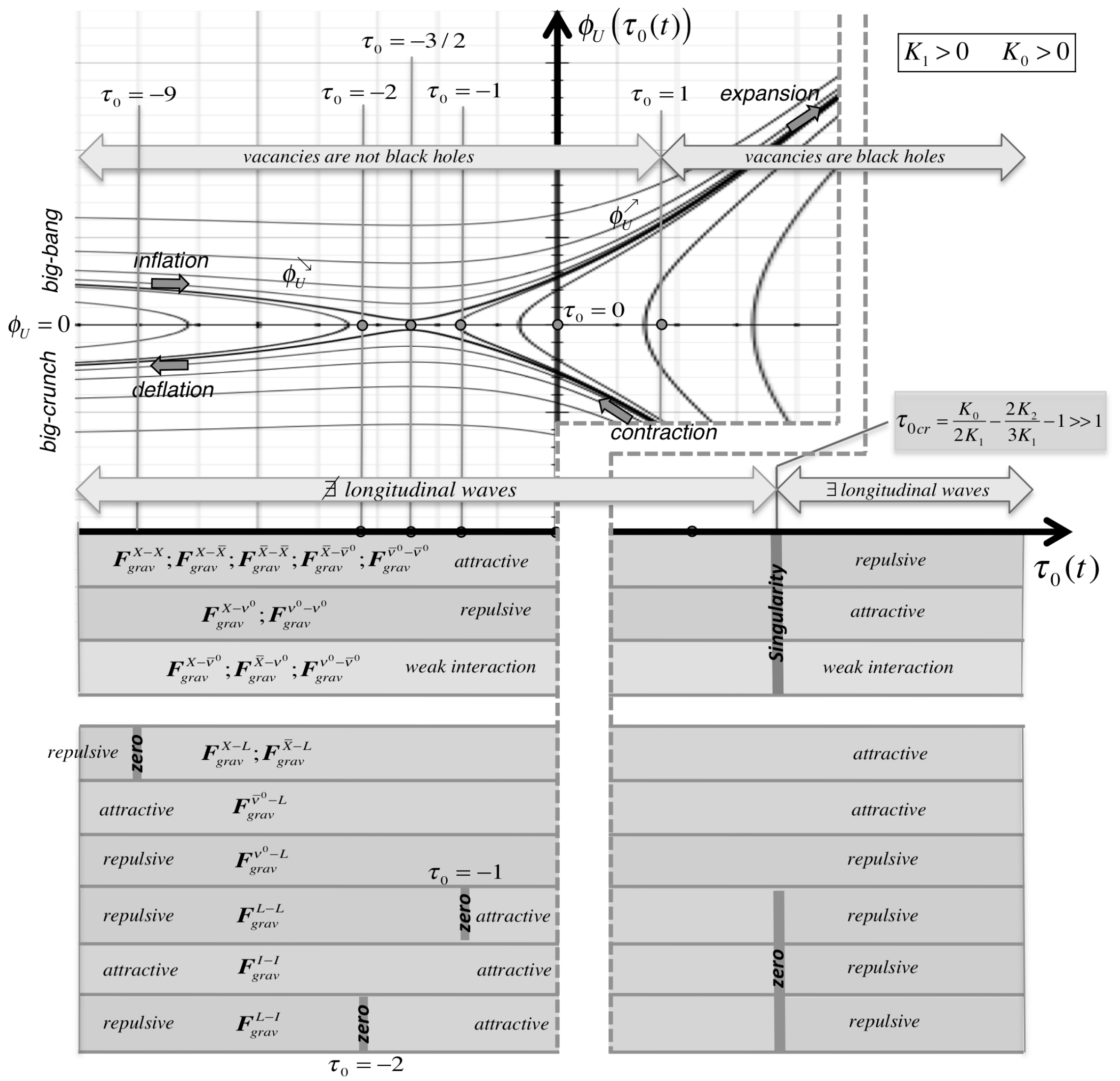

Figure 27.1 *- Behavior of gravitational forces as a function of cosmic evolution of background expansion*

Thus, 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 an anti-neutrino and a particle, the interaction can be slightly positive or negative, but with less amplitude than in the first two cases.

On a plausible scenario for the cosmological evolution of topological singularities in a perfect cosmic lattice

With the inequality relations between the gravitational interactions that we just developed we can return to the cosmic evolution of the perfect cosmic lattice (fig. 16.8 and 16.11g), and in-

clude the behavior of gravitational forces between particles. We obtain figure 27.1.
As seen in this figure there appears a series of characteristic values of expansion $\tau_0(t)$ for which there are sudden modifications, either of the behavior of cosmologic expansion, either of the behavior of the diverse forces of gravitational interaction. In this figure, we also have reported the gravitational interaction concerning the macroscopic vacancies (black holes as soon as $\tau_0(t) \geq 1$) and the macroscopic interstitials (neutron stars). Amid the characteristic values of cosmic expansion that are important, we have

- $\tau_0(t \to t_{init}) \to -\infty$, which represents the *'big-bang'* of the lattice at time t_{init},
- $\tau_0(t) = -9$, which represents the value of expansion for which the interaction force between a macro vacancy and a particle or anti-particle goes from repulsive to attractive,
- $\tau_0(t) = -2$, which represents the value of expansion for which the interaction force between a macro vacancy and a macro interstitial goes from repulsive to attractive,
- $\tau_0(t) = -3/2$ *(16.15)*, which corresponds to the transition from the *inflation phase*, during which the velocity of expansion $\phi_U(\tau_0(t))$ decreases to the *expansion phase* during which the expansion velocity $\phi_U(\tau_0(t))$ grows again,
- $\tau_0(t) = -1$, which corresponds to the transition from the repulsion stage between macroscopic vacancies to the attractive stage between macroscopic vacancies,
- $\tau_0(t) = 1$, which corresponds to the value of expansion from which macroscopic vacancies become black holes,
- $\tau_0(t) = \tau_{0cr}$, which represents the critical expansion from which we have longitudinal waves within the lattice, but no more local proper mode of vibration of expansion, and which also corresponds to the critical expansion for which many gravitational forces change sign, either by going through a singularity, or a null value.

Beyond τ_{0cr}, the cosmic evolution of the lattice goes from the *expansion phase*, during which the velocity of expansion $\phi_U(\tau_0(t))$ is positive, towards a *contraction phase* during which the velocity of expansion $\phi_U(\tau_0(t))$ becomes negative, and which finishes, after phases of *contraction and deflation*, in a *«big-crunch»* followed by a new *«big-bang»* of the lattice, and thus a *«big-bounce»* of the lattice due to the kinetic energy stored, as shown in figures 16.8 and 16.11g. On the basis of figure 27.1, we will develop a plausible scenario for the evolution of topological singularities in a cosmic lattice, which implies several steps.

On a hypothetical liquefaction and solidification of the lattice during the «big-bounce» and on the formation of an initial «hot primordial soup» of singularity loops

In the scenario of a *«big-bounce»* universe as represented in figures 16.8 and 16.11g, the intense contraction of the lattice in the end of *«big-crunch»* must heat the lattice since its kinetic energy becomes enormous, which could lead to a *«liquefaction»*. It is evident that such a phenomenon, based on our knowledge of matter, is not easy to imagine, and that the nodes of the lattice are associated with 'strange particles', which would be responsible for the mass of the lattice and could correspond to the famous Higgs particles of the standard model! For the lattice to present a transition phenomenon of *«liquefaction»*, it would be necessary for its complete state function to not only contain the free energy terms of deformation *(13.6)*, but also thermic

terms leading to its phase transition!
By assuming thus that the *«big-bang»* following the *«big-crunch»* happens from a very hot liquid of 'strange particles' which have mass, the inflation phase of the cosmologic evolution should lead to a cooling of the liquid (a reducing of its thermal agitation) and a sudden "liquid-solid" phase transition leading to the cosmic lattice which we introduced in chapter 13! During this phase transition, there could appear structural defects of the lattice as dislocations, disclinations, loops, vacancies and interstitials, and even grain boundaries, in a way that is very similar to that observed during a rapid liquid-solid transition of a metal.
We could talk about 'primordial hot soup' of the loop singularities, the term 'soup' alluding to the facts that we have an initial homogenous distribution of diverse types of loops of singularities and a great mobility of these loops as in a liquid, while the term 'hot' representing a lattice that is very hot, meaning containing a large quantity of transversal wave modes (photons) and localized modes of longitudinal vibrations (gravitons), implying *a strong thermal agitation of the initial loops.*

On the inflation and condensation of singularity loops in particles and anti-particles

During inflation, and thus the cooling of the cosmic lattice, and as soon as temperature will be low enough, the various loops will congregate within the "hot soup" to form complex localized topological dispirations, forming loops of dislocations and disclinations linked by the *weak interaction force* (section 25.3), which will correspond to the various particles of matter (electron e^-, neutrino ν^0, neutron n^0, proton p^+, etc.) and 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 a local form, which could correspond to the various particles of our Universe, will be discussed later in this book.

On the precipitation of matter and anti-matter within the sea of neutrinos and on the formation of galaxies

Within the hot soup, a homogeneous mixture of particles and anti-particles, there are particles and anti-particles whose 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 for which gravitational interaction with the 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 non existent (with the anti-neutrinos $\overline{\nu}^0$), and there is also a sea of highly energetic photons interacting strongly with the charged particles and anti-particles by the Compton diffusion mechanism. This situation linked to the component of edge loops and their curvature charge is unique to our theory, and will necessarily lead to a known phenomenon, which is really hard to explain at the moment by the other theories, which is the *initial formation of galaxies*.
Indeed, we can build a very simplified model of the initial, homogeneous hot soup of particles and anti-particles to describe the formation of galaxies. Let's consider that the initial soup forms a sort of liquid composed of attractive X on 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 of neutrinos ν^0 which are repulsive on the other hand (electronic neutrino ν_e, muon neutrino ν_μ and tau neu-

trino ν_τ ,), and let's try to express the free energy of interaction $f^{interaction}$ per particles within this liquid mixture[1]. By introducing the concentrations C_{ν^0} and $C_X = 1 - C_{\nu^0}$ of repulsive neutrinos ν^0 and attractive particles X within the mixture, the free energy of interaction can be written like a sum of a term of free energy of interaction and a term of entropy

$$f^{interaction} = \frac{z}{2} \sum_{x,y \in (\nu^0, X)} e_{x-y}^{interaction} C_x C_y - kT_{lattice} \sum_{x,y \in (\nu^0, X)} C_x \ln C_y \tag{27.11}$$

where z is the average coordination number, which represents the average neighboring number with which a particle can form an interaction of pairs and where the 1/2 factor is introduced to not count twice the same interaction.

By introducing now an average value for the inertial mass of attractive particles $\bar{M}_0^X > 0$ and of neutrinos $\bar{M}_0^{\nu^0} > 0$, as well as the average curvature $\bar{M}_{curvature}^{\nu^0} < 0$ of matter neutrinos, and by supposing an average distance $\bar{d}(\tau_0)$ between the particles in the initial hot soup, we can express very approximatively the free energy of interaction per particle under the form

$$\begin{aligned} f^{interaction} \cong \frac{z}{2} \Bigg[& -\boldsymbol{G}_{grav} \frac{(\bar{M}_0^X)^2}{\bar{d}(\tau_0)} C_X + \frac{1}{2} \boldsymbol{G}_{grav} \frac{\bar{M}_{curvature}^{\nu^0} \bar{M}_0^X}{\bar{d}(\tau_0)} C_X C_{\nu^0} + 2(\alpha_{EL} + 2\beta_{EL}) \boldsymbol{G}_{grav} \frac{\bar{M}_{curvature}^{\nu^0} \bar{M}_0^{\nu^0}}{\bar{d}(\tau_0)} C_{\nu^0} \Bigg] \\ & - kT_{lattice} \left[C_{\nu^0} \ln C_{\nu^0} + C_X \ln C_X \right] \end{aligned} \tag{27.12}$$

In this expression, the term containing the factor $(\alpha_{EL} + 2\beta_{EL})$ is negligeable with respect to the two other terms so that we write with $C_X = 1 - C_{\nu^0}$

$$\begin{aligned} f^{interaction} \cong \frac{z}{2} \Bigg[& -\boldsymbol{G}_{grav} \frac{(\bar{M}_0^X)^2}{\bar{d}(\tau_0)} (1 - C_{\nu^0}) + \frac{1}{2} \boldsymbol{G}_{grav} \frac{\bar{M}_{curvature}^{\nu^0} \bar{M}_0^X}{\bar{d}(\tau_0)} C_{\nu^0} (1 - C_{\nu^0}) \Bigg] \\ & - kT_{lattice} \left[C_{\nu^0} \ln C_{\nu^0} + (1 - C_{\nu^0}) \ln (1 - C_{\nu^0}) \right] \end{aligned} \tag{27.13}$$

If we represent this free energy as a function of concentration C_{ν^0} of neutrinos for different temperature of the lattice (figure 27.2), we notice that at high temperature the minimum free energy is obtained with a homogeneous mixture of attractive particles X and of repulsive neutrinos ν^0. But if the temperature of the lattice drops sufficiently, there appears two minima of free energy as a function of concentration C_{ν^0} : a minimum corresponding to a weak concentration of neutrinos and a minimum corresponding to a strong concentration of neutrinos. In fact there is a *phase transition by precipitation* which tends to separate the attractive particles X and the repulsive neutrinos ν^0. There will be *precipitates*, clusters of attractive particles X, within a sea of repulsive neutrinos ν^0. At low temperature, the energy minima correspond to concentrations $C_{\nu^0} = 0$ and $C_{\nu^0} = 1$, which corresponds to a complete separation of attractive particles and repulsive neutrinos!

The *phase transition by precipitation* of attractive particles and anti-particles in the form of localized clusters corresponds to the *formation of galaxies in our Universe.* In this model, it is the existence of repulsive neutrinos that becomes the driver for the formation of galaxies. And it is very interesting to note that the repulsive nature of neutrinos of matter is due exclusively to the charge of curvature of neutrinos, which is a concept that exists neither in General Relativity nor in the Standard Model. Also, we already know that the curvature charge is also at the origin of a

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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).*

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small asymmetry between matter and anti-matter, which confirms the strong link existing between this experimentally observed asymmetry and the initial formation of galaxies and of the structures of our actual Universe.

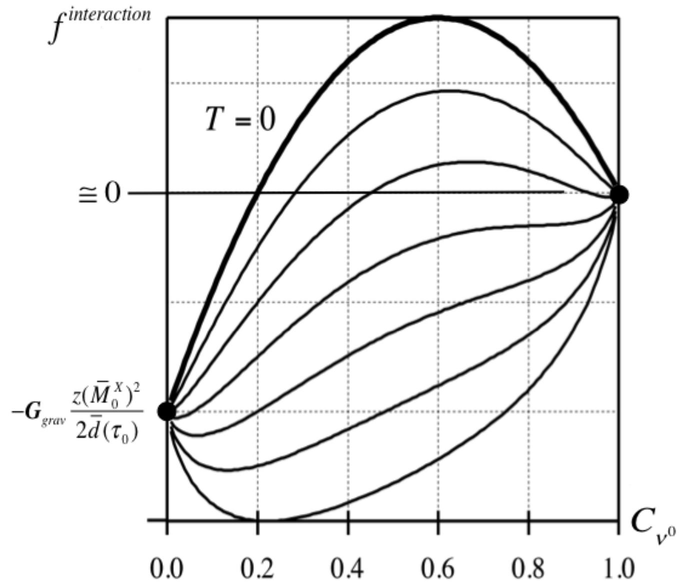

Figure 27.2 *- The free energy of interaction per particle within the initial hot soup of particles as a function of the concentration of repulsive neutrinos for different temperatures of the lattice*

On the «dark matter» of astrophysicists

With regards to the formation of a '*sea of repulsive neutrinos*' in which our galaxies bathe, it explains perfectly the phenomenon of 'dark matter' of astrophysics. Indeed when one observes a galaxy and we measure the velocities of stars that compose it as a function of their distance to the center of the galaxy, we notice that the velocities of the stars situated in the periphery of our galaxy are too high compared to the velocities obtained by applying the Newton law of gravitation with the mass of stars (which we can calculate experimentally based on their brilliance). Everything happens as if there was a halo of matter, invisible to our eyes, in the periphery of the galaxy, which, through its gravitational effect, forces the stars to rotate faster to compensate for this attractive effect. This halo of invisible matter was called *dark matter* by astrophysicists, and the quest for the nature of this dark matter is actually one of the great topics in fundamental physics. In our theory, the concept of dark matter is no longer necessary, as it is replaced by the concept of *«sea of repulsive neutrinos»* in which all the galaxies are bathed, the globular clusters, and the other structures of the visible Universe. Indeed, consider a galaxy submitted to the repulsive force of the neutrino sea. This repulsive force corresponds to a compression force which applies to the stars of the galaxy suburbs. To resist to this compression force, the peripheral stars have to turn more quickly than the velocity calculated by Newton's gravity on the basis of the visible mass, in order to equilibrate the compression force of the repulsive neutrino sea by an additional centripetal force of rotation.

On the formation and separation of matter and anti-matter within galaxies

Let's look at what happens inside birthing galaxies, during this phenomenon of precipitation of attractive particles and anti-particles. Within the liquid phase that is precipitating, the attractive gravitational interactions present slight differences, depending on whether we are dealing with particles or anti-particles. Let's consider for example a family of particles X and anti-particles $\bar{X}$. The gravitational forces of interaction between these particles can be written, from *(27.3)*

$$\begin{cases} \boldsymbol{F}_{grav}^{X-X} \cong \boldsymbol{G}_{grav} \dfrac{\left(M_0^X\right)^2}{d^2} - \boldsymbol{G}_{grav} \dfrac{M_{curvature}^{\bar{X}} M_0^X}{d^2} \\ \boldsymbol{F}_{grav}^{X-\bar{X}} \cong \boldsymbol{G}_{grav} \dfrac{\left(M_0^X\right)^2}{d^2} \\ \boldsymbol{F}_{grav}^{\bar{X}-\bar{X}} \cong \boldsymbol{G}_{grav} \dfrac{\left(M_0^X\right)^2}{d^2} + \boldsymbol{G}_{grav} \dfrac{M_{curvature}^{\bar{X}} M_0^{\bar{X}}}{d^2} \end{cases} \tag{27.14}$$

With the mass of inertia M_0^X of these particles, we deduce, thanks to the classic Newton equation, the acceleration that these particles undergo during their interaction

$$\begin{cases} \boldsymbol{a}_{grav}^{X-X} \cong \dfrac{\boldsymbol{G}_{grav}}{d^2}\left(M_0^X - M_{curvature}^{\bar{X}}\right) \\ \boldsymbol{a}_{grav}^{X-\bar{X}} \cong \dfrac{\boldsymbol{G}_{grav}}{d^2} M_0^X \\ \boldsymbol{a}_{grav}^{\bar{X}-\bar{X}} \cong \dfrac{\boldsymbol{G}_{grav}}{d^2}\left(M_0^X + M_{curvature}^{\bar{X}}\right) \end{cases} \tag{27.15}$$

We deduce that the anti-particles $\bar{X}$ attract each other more strongly than the particles X, and we must therefore see a progressive segregation phenomenon of anti-particles and particles, during which the anti-particles will have a tendency to regroup in the center of the nascent galaxy, leaving the particles in its periphery!

It is clear that this segregation phenomenon must be accompanied by an intense activity of annihilation between particles and anti-particles, in a zone situated around the center of the galaxy, and that would necessarily be *a source of gamma radiation*. But there also must be a combining activity between particles and anti-particles to form matter and anti-matter (initially of hydrogen and anti-hydrogen atoms and helium and anti-helium atoms). These processes of annihilation and recombination must follow through until there is an effective separation between the heart of the galaxy, composed essentially of anti-matter and the periphery of the galaxy composed essentially of matter. We again notice that this separation of matter and anti-matter is *due to the existence of the curvature charge of the edge dislocation loops*, since these charges are responsible for the equivalent mass of curvature $M_{curvature}^{\bar{X}}$, which is itself responsible for the small difference of gravitational interaction between matter and anti-matter!

On the formation of a cosmological radiation background

Initially, all the particles and anti-particles are in thermal equilibrium with a sea of photons, via interactions by Compton diffusion, while their temperature has not dropped enough to form

atoms. But as soon as the temperature drops below 3'000 K, there is formation of helium, anti-helium, hydrogen and anti-hydrogen, assuring us of the electric neutrality of matter and anti-matter. At that instant there is also a decoupling of photons and neutral matter and anti-matter. The universe becomes
transparent to photons, which fill the whole space in the form of a *cosmic radiation background.* This cosmic radiation background is known as the cosmological microwave background and has been studied and observed experimentally. It is almost isotropic and present the spectrum of a perfect black body radiation, meaning a *Planck distribution of density of energy* $U(\nu)$ *of photons*, centered on a temperature T which is measured currently at a value of 2,7 K

$$U(\nu)=\frac{8\pi h\nu^3}{c^3}\frac{1}{\mathrm{e}^{\frac{h\nu}{kT}}-1}d\nu \qquad (27.16)$$

with c being the speed of light, h the Planck's constant, k the Boltzmann constant, T the temperature of the black body and ν the frequency of photons.
We will revisit, in the next section, the process by which the background radiation 'cools'.

On the gravitational collapse and the disappearance of anti-matter by the formation of gigantic black holes in the center of galaxies

The formation by precipitation of galaxies composed of particles and anti-particles that attract within the sea of repulsive neutrinos will lead to large pressures at the heart of galaxies as they evolve. The emergence of twist in galaxies allows to partially balance the attractive gravitational forces within the galaxies and the compression force of the sea of neutrinos. But at the center of the galaxies, the compression forces could reach values large enough to lead to a gravitational collapse at the heart of the galaxies. If such a collapse happens, as the heart of the galaxies is formed essentially of anti-matter, it will be responsible for the appearance of macroscopic lattice vacancies, as during the collapse the disclination twist loops will annihilate each other (if anti-matter is electrically neutral), while the vacancy edge dislocation loops, which characterize anti-matter, combine to form the 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 a giant topological singularity* which becomes a *large black hole* as soon as the expansion of the background exceeds unity ($\tau_0 \geq 1$). *This phenomena of gravitational collapse of anti-matter at the heart of galaxies would explain simply, and at once both, the experimental observation that there exist gigantic black holes at the center of galaxies and that anti-matter seems to have disappeared from our present Universe.*

On the coalescence of matter in galaxies and on the formation of stars

The matter which composes galaxies after the collapse of the heart of anti-matter in a black hole will coalesce bit by bit under the effect of gravitational attraction to form hydrogen gas and helium gas, various types of stars and planetary systems, such as observed in our actual universe.

On the gravitational collapse of stars and on the formation of neutron stars

As the galaxies are essentially made of matter, based on interstitial edge dislocation loops, all gravitational collapse of a large star under the effect of its own gravity will lead to a localized topological singularity of macroscopic interstitial type and not of the vacancy type. As a consequence, there cannot be the emergence of a vacancy black hole after the gravitational collapse of a massive star of matter!

Experimentally, we sometimes suddenly observe this gravitational collapse of massive stars of matter under the form of *'supernovas'* and in the form of the residual gas after the initial explosion of the star, which extends at great velocity, with, in the center of the supernova a rather small and massive object, which should correspond to a residual interstitial singularity, which we usually call a *pulsar* (due to its emission properties of electromagnetic pulses corresponding to a frequency of rapid rotation of the object on itself) or *neutron stars* (due to the high mass density of the object).

The rest of the story is well known and described by astrophysicists with the formation of atoms of increasing size by nuclear fusion of hydrogen and light elements inside the stars, and by the dispersion of these elements by supernovas, which leads finally to the apparition of all elements of the table of Mendeleïev and the formation of stars which are more and more complex, planetary systems, etc

On the future of our universe

In the scenario of the universe *«big-bounce»* which was depicted in figures 16.8 and 16.11g, which corresponds actually to our own universe, the expansion phase with constant velocity, in the condition where there are no longitudinal waves, is found between values $\tau_0 = -3/2$ and $\tau_0 = \tau_{0cr} >> 1$. Our actual universe must then be in this range of values of the background expansion since recent observations have shown that the expansion of the universe is probably done at increasing speed. We can even say that the expansion of the background should be in the domain $1 < \tau_0 < \tau_{0cr}$, since massive black holes seem to have been observed in the center of most galaxies, notably in the center of our galaxy, the milky way!

As this range ($1 < \tau_0 < \tau_{0cr} >> 1$) is very large, it is hard to know where we are actually and how much time we will need to reach critical expansion τ_{0cr}. What we can already say however is that when it gets close to τ_{0cr}, there will appear titanic transformation of celestial bodies, of matter, of black holes and of the sea of repulsive neutrinos since the following will be:

- the gravitational constant G_{grav} will become negative by going through a singularity at τ_{0cr},
- the localized vibration models will disappear to the profit of longitudinal models (which should correspond to the disappearance of quantum physics as we will see later in this treatment!).

These two phenomenas should be cataclysmic. But we can go further by considering the phenomena appearing during the re-contraction phase of the cosmic lattice, specifically during the transition through τ_{0cr} in the inverse direction, where the gravitational constant becomes positive again and where there appears again proper modes of localized vibrations in lieu of longitudinal waves. These predictions are possibly in the domain of the possible with our theory, but surely very hard and approximative. Actually, we are now in science fiction land.

It remains so that our theory goes much further in the explanations and predictions than General Relativity and that many exotic phenomenas such as instantaneous displacement in space time via wormholes as described in general relativity, and which delight theoretical physicist and science fiction writers alike, are pure delirium (aka bullshit) in our theory.

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