XI - ON THE ORIGIN OF PARTICLES STANDARD MODEL AND STRONG FORCE IN A LATTICE UNIVERSE

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We have shown previously that the perfect lattice presents strong analogies with the great theories of modern physics, namely the equations of electro-magnetism, general relativity, special relativity, black holes, cosmology, dark energy and quantum mechanics, and that we can have 3 types of basic topological loop singularities which possess respectively the analogue of an electrical charge, an electric dipole moment or a curvature charge by flexion. It should be noted that the curvature charge is unique to our theory, and explain rather simply several mysterious phenomena, such as the weak coupling force of two topological loops, the dark matter, the galactic black holes, and the disappearance of anti-matter.

In this chapter, we will strive to find and describe the ingredients which could explain, on the basis of topological singularities, the existence of the standard model of particle physics. In other words, we will strive to find mechanisms to generate the fundamental particles such as leptons and quarks, and what could cause three generations of these fundamental particles, and from whence could come the strong force which binds quarks to form baryons and mesons.

This chapter does not pretend to give an elaborate theory or a final, quantitative solution to explain the standard model of particle physics, but rather to show with a few specific arguments that it could be the choice of a microscopic structure of the lattice that could answer the questions of the standard model. Here we will show that there appears a full 'zoology' of loops in a well choosen structure of the lattice, and that it resembles the elementary particles of the standard model. We will show the presence of an asymptotic strong force which could bind the topological loops!

On the problems of the standard model of fundamental particles

Currently, particle physics explains the fine structure of matter with the help of a model called *"the Standard Model of Particle Physics"* (see annex C). In this model there appears *fermions,* particles of matter which present different families, the family of *leptons* and the family of *quarks*, as well as 3 types of interactions which can appear between fermions: the electromagnetic interaction, the weak interaction and the strong interaction.

The interactions between fermions happen via the exchange of particles called *gauge bosons*, corresponding to the quantas of the quantum fields of interaction. The electromagnetic interaction involves *photon* γ *,* the weak interaction the three gauge bosons Z^0 , W^+ and W^- , and the strong interaction involves 8 gauge bosons called "*gluons*".

The mass of particles is introduced in the standard model via a new interaction associated with the quantum Higgs fields, and the mediating particle is called the *'Higgs boson'*.

On the problems related to the Standard Model that already have a solution in our theory

In spite of its undeniable success, the standard model has many open questions. In this chapter we will try to see if an approach to the standard model via our theory of the cosmic lattice can bring an answer to these various questions. We are not trying here to give a final answer to these problems, but to show, very qualitatively, how the cosmic lattice would go about answering these questions. Some of the open problems of the standard model already have some answers as shown in the previous chapters.

Let's then take a look at those problems that have a partial answer in our theory and how the lattice gives some answers to these various problems:

- *On the absence of gravitational interaction in the standard model: g*ravitational interaction is intrinsically woven to the theory of the cosmic lattice, as the static solution to the Newton equations of motion, and it is this equation, under its dynamical form that allowed us to introduce a simple explanation to quantum mechanics and the notion of spin of loop singularities.

- *On the necessity of the Higgs boson and the impossibility to calculate the masses of the different fermions and bosons in the standard model: i*n the basic standard mode, fermions have no mass, and theoretical physicists had to introduce an ad-hoc mechanism, the interaction with the Higgs field via the Higgs boson, which confers inertial mass to elementary particles. However, in the standard model, it is not possible to obtain quantitative values for the inertial mass of the particles, which are experimentally derived values. The cosmic lattice theory contains in fact a mechanism analogous to the Higgs field: it is the field of inertial masses of 'objects' of the lattice (which are then analogous to Higgs boson with spin 0) as well as the elastic energy of distortion of the lattice which are together responsible for the inertial relativistic properties of topological singularities, without having to set values to experiments.

- *On the physical nature of electromagnetic interaction in the standard model:* electromagnetic interaction, as well as its boson carrier, the photon, with it's diverse quantum properties, are part of the cosmic lattice theory, and have a very simple physical explanation on the basis of the field of rotation within the cosmic lattice.

- *On the physical nature of the weak interaction of the standard model:* a weak interaction presenting an analogy with the weak interaction of the standard model was obtained in the cosmic lattice theory (chapter 26), under the form of a force with very short range, linking «topological fermions» together (twist disclination loop TL to edge dislocation loop EL), via a coupling of their respective charges of rotation and curvature.

- *On the violation of **CP** invariance (charge/parity) in the standard model:* in the real universe, we observe a violation of the **CP** invariance (charge/parity) which theoreticians estimate to be the probable cause for the asymmetry of matter and anti-matter. In the cosmic lattice, this weak asymmetry between matter and anti-matter exists, and can be explained by the existence of a curvature charge due to edge loops. This charge has no equivalent in the standard model. This phenomenon also explains the dark matter of astrophysics and the disappearance of anti-matter during the cosmic evolution of the universe.

- *On the absence of explanation of dark energy and dark matter in the standard model:* these

two concepts invented by theoretical physicists to explain the acceleration of expansion and the gravitational behavior of galaxies have explanations in the cosmic lattice: the energy of elastic *distortion for dark energy and the gravitational repulsion of neutrinos as regards dark matter.*

On the problems of standard model which are not yet explained by the cosmic lattice theory

Amongst the problems of the standard model of particle physics, there are some which do not yet find a plausible explanation in the cosmic lattice. We have:
- *the existence of fermions under the form of three generations of leptons and quarks:* if fermions correspond to topological singularities in the theory of the cosmic lattice, the existence of fermions under the form of leptons and quarks, as well as the existence of three generations of fermions, should find an explanation with a particular choice of the cosmic lattice structure and the building of elementary particles as topological singularities in the form of dispiration loops.
- *the existence of three massive gauge bosons in the weak interaction:* as the weak interaction already appeared in our theory as a force linking the twist loops to the edge loops, we must find what are the massive gauge bosons, carriers of this interaction, in the cosmic lattice theory.
- *the existence of a strong interaction linking quarks by a confinement mechanism:* the strong interaction, with its confinement mechanism and its carrier bosons, the gluons, are the only interaction which has not appeared in our theory. But we already have encountered mechanisms which could be potential candidates to explain this force and its asymptotic behavior, as the mechanisms that generate a stacking fault energy within the lattice, such as the dissociation of a dislocation for example.
- *the existence of quantified electrical charges with relative values,1, 1/3 and 2/3:* the electrical charge of fermions possess relative values 1, 1/3 and 2/3 between the charge of electrons and the charge of quarks. These quantified values do not have any explanation in the standard model, but one can conjecture that a judicious choice of a particular structure for the cosmic lattice could explain this problem.
In the rest of this chapter, we will try to find answers to these interrogations about the standard model, by exclusively focusing on the structure of the cosmic lattice and on the properties of the topological singularities contained therein.
In the standard model, 26 different parameters are required (in the case where neutrinos have a mass) to obtain a functional theory, such that the mass of particles and the intensity of the various forces, and these parameters become 'set' on the values observed and obtained experimentally. We can conjecture that the cosmic lattice model will reduce the number of parameters one can adjust, simply because it can explain phenomena that the standard model cannot directly explain!

On a 'colored' cubic lattice to explain the first family of quarks and leptons of the standard model

In the perfect cosmic lattice, we have seen that the topological singularity that explains the electrical charge is the twist disclination loop (TL). As we have seen in chapter 24, for the gravitational interaction of TL to map to observed behaviors (time dilatation, curvature of wave rays), it

suffices that coefficients α_{TL} and β_{TL}, in the expressions $R_{TL} = R_{TL0}\,e^{\alpha_{TL}\tau}$ and $\boldsymbol{\Omega}_{TL} = \boldsymbol{\Omega}_{TL0}\,e^{\beta_{TL}\tau}$ giving the dependency of the radius and angle of torsion of the TL as a function of the background expansion, have to satisfy the relation $3\alpha_{TL} + 2\beta_{TL} = 1/8$. This implies that torsion $\boldsymbol{\Omega}_{TL}$ could

(i) be a constant independent of expansion, in which case, $\alpha_{TL} = 1/24$ and $\beta_{TL} = cste$, which allows for a topological explanation of the discrete, and independent of expansion, values for angle $\boldsymbol{\Omega}_{TL}$,

(ii) either depend on volume expansion, in which case $\boldsymbol{\Omega}_{TL}$ cannot take a discrete value which would be directly linked to the structure of the lattice, since this angle would disappear in a continuous fashion during volume expansion.

Thus if quantized values appear, such as the charge of the electron, but also fractional charges 1/3 and 2/3 as it is the case for the quarks in the standard model, we would need that the rotation angle of the two internal planes intrinsic to the twist loop corresponds to symmetries of the lattice itself, for example $\pi/2$, π, $3\pi/2$, ... in the case of a cubic lattice, or $\pi/3$, $2\pi/3$, π, … in the case of a hexagonal lattice.

We will choose as a consequence the following hypothesis concerning the cosmic lattice

Conjecture 12: The angle $\boldsymbol{\Omega}_{TL}$ takes discrete values linked to the symmetry of the lattice and independent in volume expansion $(\beta_{TL} = cste)$ *(31.1)*

On peculiar rules of stacking and rotation in a 'colored' cubic lattice

Let us imagine *à priori* a cubic lattice which is rather peculiar (fig. 31.1), with a lattice step of a, which would be constituted of *«colored planes of particles»* indexed with 3 fundamental colors ***R***, ***G***, ***B*** (these artificial colors are just a convenient representation and do not, at least as of yet, have any relationship with the 'colors' used by the standard model to explain the color charge of quarks and gluons). Even if we do not know the physical reason for the existence of "colored planes", we will suppose that this alternation of colors of the planes of particles is a necessary condition of existence of the cosmic lattice in the absence of topological singularities, and that if the alternation ***R***, ***G***, ***B*** of the planes of the lattice is broken by the presence of a topological singularity, there could appear fault energies between the planes of particles. Let's also postulate *à priori* stacking and rotation rules of the colored plane in this very peculiar lattice as such:

Conjecture 13: The stacking of planes ***R***, ***G***, ***B*** follows three elementary rules: *(31.2)*

Rule 1: the *alternation of planes* ***R***, ***G***, ***B*** *cannot be broken* (either by impossibility or by a very large energy associated with a surface stacking fault energy γ_1),

Rule 2: in a given direction of space, there may appear a stacking fault corresponding to a shift in the alternation of planes ***R***, ***G***, ***B*** , which possesses a *surface stacking fault energy* γ_0 *which is not null* (fig. 31.1, image 4).

Rule 3: if a plane with a given color undergoes a rotation by an angle $\pm\pi/2$, $\pm\pi$ or $\pm 3\pi/2$, *it changes color* according to table 31.1, which corresponds to the existence of a given axial property of the lattice.

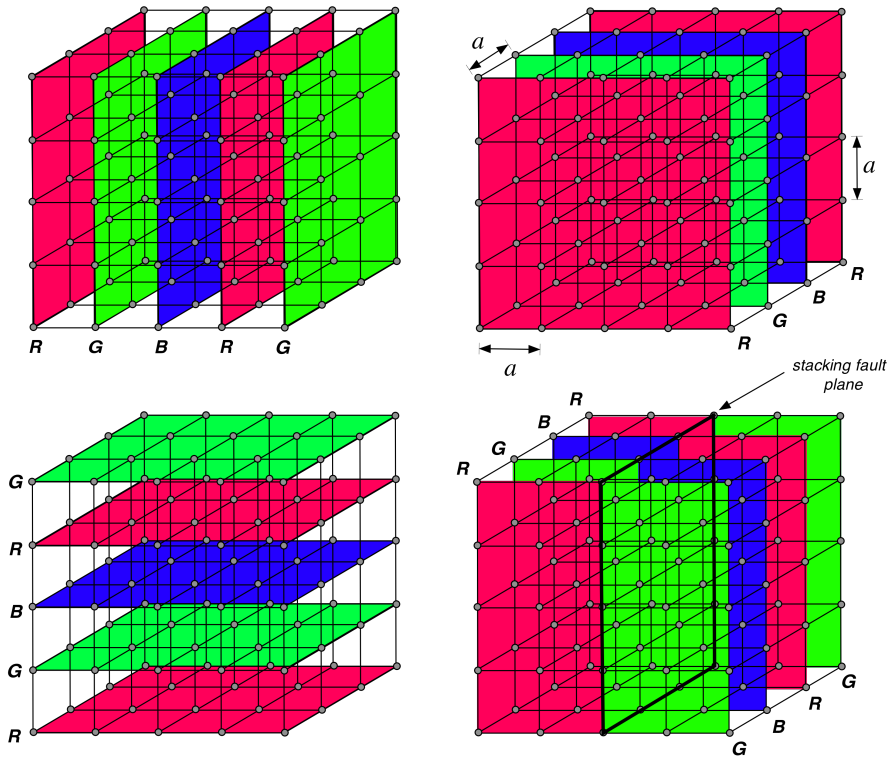


Figure 31.1 - *a cosmic lattice, cubic and isotropic, with planes* ***RGB*** *presenting a regular stacking in the 3 directions of space, as well as a stacking fault of the colored planes.*

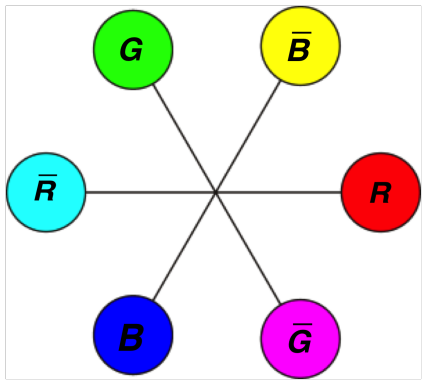
rotation angle Ω_{TL}	***color change***	***colors R, G, B and complementary colors*** $\overline{R}$, $\overline{G}$, $\overline{B}$
$+3\pi/2$ 0 $-3\pi/2$	$R \to R$ $G \to G$ $B \to B$	
$+\pi/2$ $-\pi$	$R \to G$ $G \to B$ $B \to R$	
$-\pi/2$ $+\pi$	$R \to B$ $G \to R$ $B \to G$	

Tableau 31.1 - *the color changes of a plane by rotation, and the complementary colors to red, green and blue, namely cyan, magenta and yellow.*

On the necessity to combine a twist disclination loop and an edge dislocation loop in such a lattice and the existence of quarks

We can introduce a twist loop (TL) in our lattice (represented symbolically in figure 31.2,h with an angle of rotation of the inferior plane by $\pm\pi/2$, or $\pm\pi$, or $\pm 3\pi/2$. But according to rule 3, a rotation of $\pm\pi/2$ or $\pm\pi$ induced on the inferior planes of the loop will change their color, with, according to rule 2, the genesis of a cylinder of stacking faults with a surface fault energy γ_0, as schematically shown in figures 31.2, a through d.

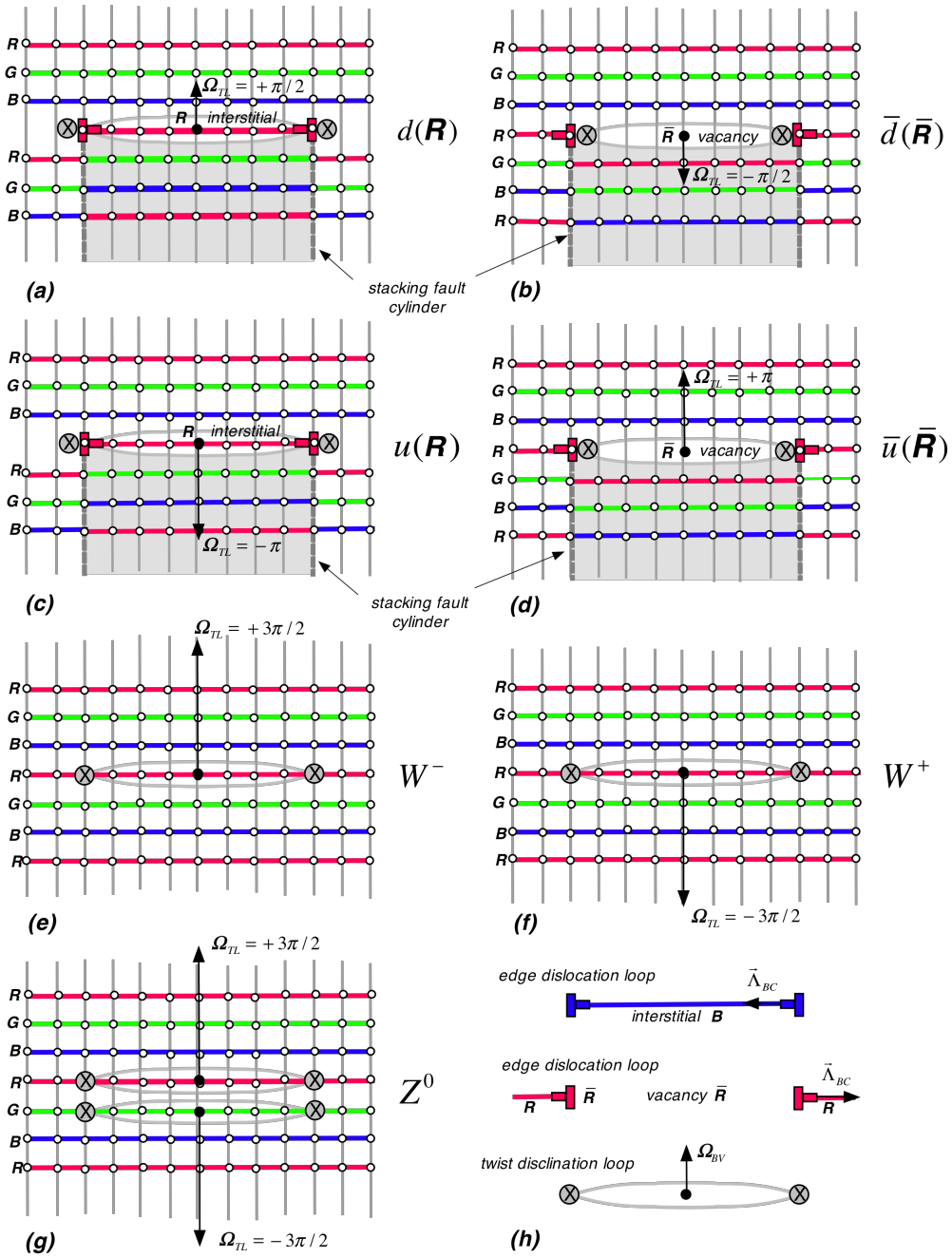


Figure 31.2 *- the combinations of twist disclination loops with angles $\pm\pi/2$, $\pm\pi$ or $\pm 3\pi/2$ with edge dislocation loops that assure the continuity of alternation of planes* ***RGB.***

The change of color of the lower planes in the case of rotations $\pm\pi/2$ or $\pm\pi$ implies that if rule 1 is violated at the level of the twist loop, and in order to satisfy the stacking of colored planes, we must associate an edge loop to the twist loop (represented symbolically in figure 31.2, h), of interstitial type if the angle of rotation is $+\pi/2$ or $-\pi$ (fig. 31.2, a and c), or of vacancy type if the angle of rotation is worth $-\pi/2$ or $+\pi$ (fig. 31.2, b and d).
The interstitial plane in the case of an interstitial edge loop will have one of 3 colors ***R***, ***G***, ***B,*** while the missing plane in the case of a vacancy edge loop will have the anti-color of the plane which was interrupted, namely colors $\overline{\boldsymbol{R}}$, $\overline{\boldsymbol{G}}$ or $\overline{\boldsymbol{B}}$ (we use in the figures the complementary colors to ***R***, ***G***, ***B,*** which are *cyan, magenta and yellow*, see table 31.1). In the four cases (fig. 31.2, a to d), the twist loop is evidently linked to the edge loop by the weak force described in section 25.3, but also by the necessity to introduce the edge loop to assure the alternance of colors of planes at the level of the twist loop!
The dispirations thus formed, possess a 'color', which corresponds to the color of the interstitial plane or the anti-color of the vacancy plane (the anti-color or complementary color to the color of the plane in which the vacancy loop appears).
With respect to the disclination loops with angle $\pm 3\pi/2$ (fig. 31.2, e to g), they do not need to be combined with edge loops since these rotations do not entail any color change in the inferior planes, and thus as a consequence no cylinder of stacking faults under it.

name	Ω_{TL}	$q_{\lambda TL}$	***edge loop***	$q_{\theta EL}$	***color***
d	$+\pi/2$	$-\pi^2 R_{TL}^2/2$	*interstitial*	$-2\pi a$	***R***, ***G*** or ***B***
u	$-\pi$	$+\pi^2 R_{TL}^2$	*interstitial*	$-2\pi a$	***R***, ***G*** or ***B***
$\overline{d}$	$-\pi/2$	$+\pi^2 R_{TL}^2/2$	*vacancy*	$+2\pi a$	$\overline{\boldsymbol{R}}$, $\overline{\boldsymbol{G}}$ or $\overline{\boldsymbol{B}}$
$\overline{u}$	$+\pi$	$-\pi^2 R_{TL}^2$	*vacancy*	$+2\pi a$	$\overline{\boldsymbol{R}}$, $\overline{\boldsymbol{G}}$ or $\overline{\boldsymbol{B}}$
W^-	$+3\pi/2$	$-3\pi^2 R_{TL}^2$	-	0	-
W^+	$-3\pi/2$	$+3\pi^2 R_{TL}^2$	-	0	-
Z^0	$(+3\pi/2)+(-3\pi/2)$	0	-	0	-

Table 31.2 - *The seven singularities composed of a twist loop and combined (or not) with an edge loop*

On the existence of intermediary gauge bosons

In table 31.2, we have shown the different properties of topological singularities thus formed, by

giving them as in figure 31.2, a name chosen “randomly”, and by using the fact that the two dispirations on the right (a and c) in figure 31.2 are clearly anti-loops of the left loops (b and d).
In table 31.2, we notice that the charges of rotation $\boldsymbol{q}_{\lambda TL}$, analogous to the electrical charge, present 3 different values, corresponding respectively to 1/3x, 2/3x and 1x the charge of loops W^- or W^+. Also, only the dispirations d, u, $\overline{d}$ and $\overline{u}$ present a charge $\boldsymbol{q}_{\theta EL}$ of curvature via a non-null flexion and the sign of these charges, positive in the case of a vacancy edge loop and negative in the case of an interstitial edge loop, imply as we have already postulated in conjecture 8, that the particles d and u correspond by analogy to matter and that their anti-particles $\overline{d}$ and $\overline{u}$ correspond to anti-matter. With respect to particles W^-, W^+ and Z^0 which do not posses a curvature charge $\boldsymbol{q}_{\theta EL}$, they must have an important mass since they are twist disclination loops with a high angle of rotation $\boldsymbol{\Omega}_{TL}$.

On the weak interaction of quarks via intermediary bosons

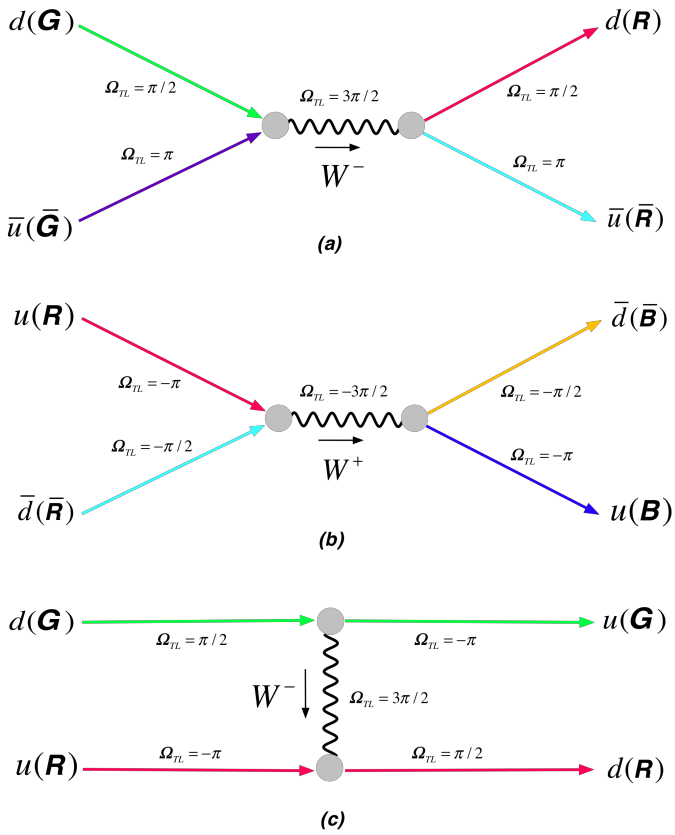


Figure 31.3 - *Feynman diagrams of the combination and exchange between quarks of table 31.2*

It is interesting to note here that the combination of two disparitions d and $\overline{u}$, or $\overline{d}$ and u, contribute to create a pure twist loop W^- or W^+, which can again transform in a pair d and $\overline{u}$, or $\overline{d}$ and u. We can also imagine an exchange of a loop W^- or W^+ between two dispirations d and $\overline{u}$, or $\overline{d}$ and u, which will change their nature, or to speak more poetically their “flavor”.
These combinations and exchanges are illustrated in figure 31.3 in the form of *Feynman dia-*

grams. They are characterized by the fact that the total rotation Ω_{TL} is conserved, which assures us at the same time the conservation of rotation charge $q_{\lambda TL}$. We also note that the total charge $q_{\theta EL}$ is conserved in the reactions. It is then undeniable that these reactions have a strange similarity with the weak interactions of the standard model as shown in table C.3!

On the existence of «baryons» and localized «mesons», formed from 3 and 2 dispirations

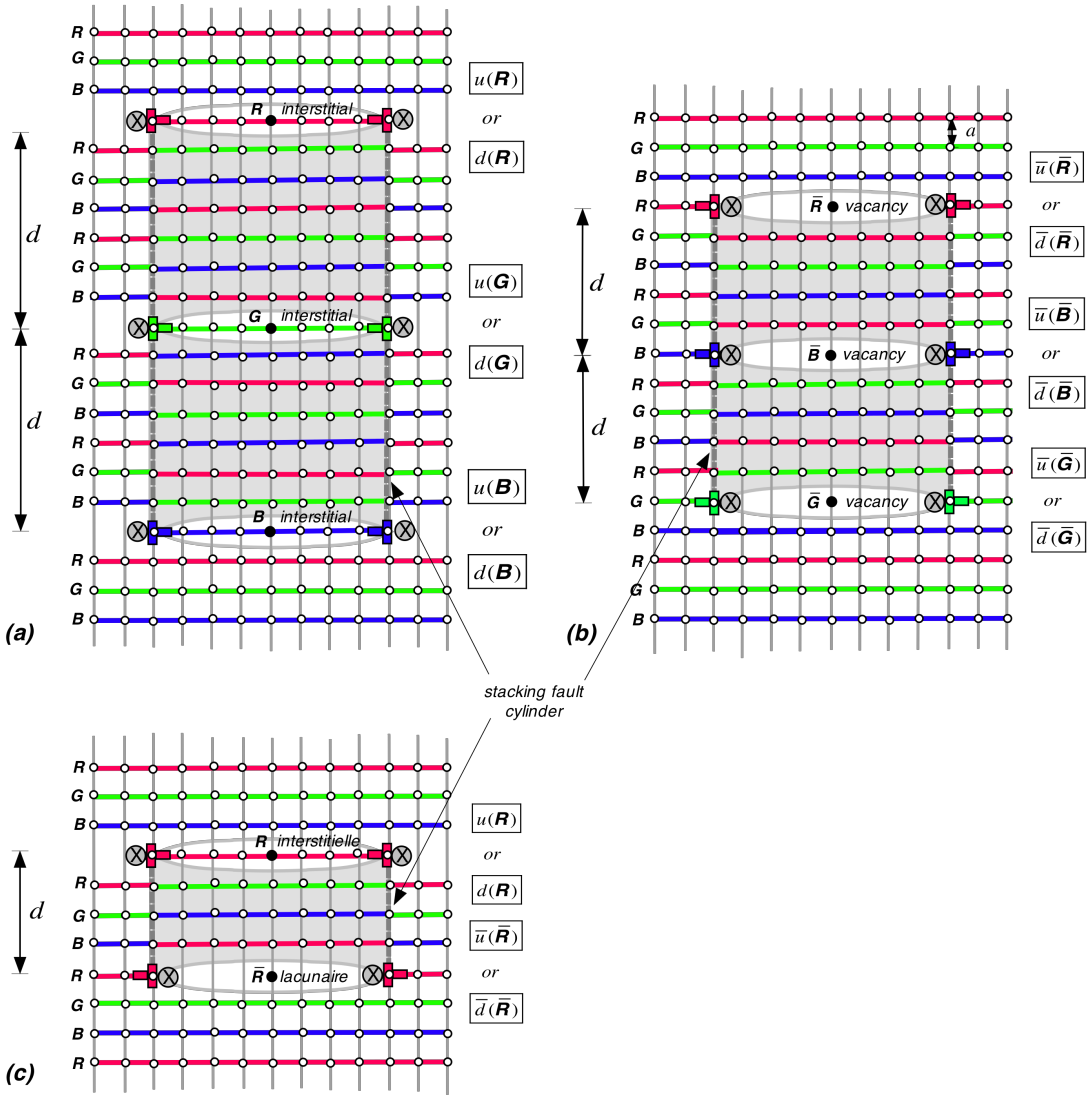


Figure 31.4 - *the 3 possibilities of combination of 2 or 3 dispirations allowing one to form topological singularities which are local*

Each of the dispirations (a to d) of table 31.2 gives us a cylinder of stacking faults which possesses an energy proportional to the lateral surface of the cylinder (fig. 31.2). As a consequence, it is impossible for these disparitions to disappear in an isolated fashion, as the cylinder would then have a very large length $\sim R_{\infty}$, and thus a great energy! We can then wonder how we can generate singularities composed of such dispirations, and that they be of a reasonable energy!

In fact, there exists 3 ways of combining the 4 dispirations of table 31.2 so that the topological singularity thus formed be localized, meaning a tube of stacking faults with finite length:
- *the combination of 3 singularities* u *or* d (fig.31.4,a),
- *the combination of 3 anti-singularities* $\overline{u}$ *or* $\overline{d}$ (fig.31.4,b),
- *the combination of a singularity* u *or* d *with an anti-singularity* $\overline{u}$ *or* $\overline{d}$ (fig.31.4,c).

For the 3 rules we formulated earlier to be satisfied in these various combinations, it is necessary that:
- *the sum of the angles* $\boldsymbol{\Omega}_{TL}$ *of rotation of all the dispirations be null or a multiple of* $3\pi/2$, which allows the tube to be of finite length,
- *that the color of the assembly thus formed be "white"*, so that the assembly has the 3 colors ***R***, ***G***, ***B*** (fig.31.3,a), or be the sum of the 3 anti-colors $\overline{\boldsymbol{R}}$, $\overline{\boldsymbol{G}}$, $\overline{\boldsymbol{B}}$ (fig.31.3,b), or the sum of a color ***R***, ***V***, ***B*** with its respective anti-color $\overline{\boldsymbol{R}}$, $\overline{\boldsymbol{G}}$, $\overline{\boldsymbol{B}}$ (fig. 31.3,c).

combination	***symbol***	$\boldsymbol{\Omega}_{TL}$	$\boldsymbol{q}_{\lambda TL}$	***edge loop***	$\boldsymbol{q}_{\theta EL}$
$d\,d\,d$	Δ^-	$+3\pi/2$	$-3\pi^2 R_{TL}^2/2$	*interstitial*	$-6\pi a$
$d\,u\,d$	n,Δ^0	0	0	*interstitial*	$-6\pi a$
$u\,d\,u$	p,Δ^+	$-3\pi/2$	$+3\pi^2 R_{TL}^2/2$	*interstitial*	$-6\pi a$
$u\,u\,u$	Δ^{++}	-3π	$+3\pi^2 R_{TL}^2$	*interstitial*	$-6\pi a$
$\overline{d}\,\overline{d}\,\overline{d}$	$\overline{\Delta}^+$	$-3\pi/2$	$+3\pi^2 R_{TL}^2/2$	*vacancy*	$6\pi a$
$\overline{d}\,\overline{u}\,\overline{d}$	$\overline{n},\overline{\Delta}^0$	0	0	*vacancy*	$6\pi a$
$\overline{u}\,\overline{d}\,\overline{u}$	$\overline{p},\overline{\Delta}^-$	$+3\pi/2$	$-3\pi^2 R_{TL}^2/2$	*vacancy*	$6\pi a$
$\overline{u}\,\overline{u}\,\overline{u}$	$\overline{\Delta}^{--}$	$+3\pi$	$-3\pi^2 R_{TL}^2$	*vacancy*	$6\pi a$

Table 31.3 - *White baryons formed of 3 dispirations*

In table 31.3, we have reported the 8 different combinations that are possible with the 3 dispirations of table 31.2, with their properties, by giving them a symbol and calling them *baryons*, by analogy with standard model.
In this table, the analogy with baryons of the standard model, composed with quark triplets of u and d or triplets of anti-quarks $\overline{u}$ and $\overline{d}$, is obvious and perfect! Not only do we see particles composed of *quarks* with fractional charges of rotations $\boldsymbol{q}_{\lambda TL}$ corresponding to the electrical

charges of the standard model, but it is here added to the charge of curvature by flexion $\boldsymbol{q}_{\theta EL}$ which does not have an equivalent in the standard model, and which corresponds perfectly with our conjecture 8 (22.91), namely that the *singularities of vacancy nature correspond by analogy to the anti-matter and the singularities of interstitial nature to matter!* The fact that the particles of the standard model appear with two different symbols in this table for combination $d\,u\,d$, $u\,d\,u$, $\overline{d}\,\overline{u}\,\overline{d}$ and $\overline{u}\,\overline{d}\,\overline{u}$ is explained by the notion of spin of the twist loops developed in chapter 29. Indeed, if each quark possesses a spin $\pm 1/2$, then the composition of the spins can create a global spin $\pm 1/2$ in the case of particles n *(neutron) and* p *(proton)* and the anti-particles $\overline{n}$ *(anti-neutron)* and $\overline{p}$ *(anti-proton)*, or a spin $\pm 3/2$ in the case of particles Δ^0 and Δ^+ and of anti-particules $\overline{\Delta}^0$ and $\overline{\Delta}^-$. In the case of combinations $d\,d\,d$, $u\,u\,u$, $\overline{d}\,\overline{d}\,\overline{d}$ and $\overline{u}\,\overline{u}\,\overline{u}$, the spins of the 3 quarks are necessarily aligned (for a reason that remains to be explained, but which is strongly linked to the principle of exclusion!) and the composition of the spins can then only yield a global spin of $\pm 3/2$ in the case of particles Δ^- and Δ^{++} and of anti-particules $\overline{\Delta}^+$ and $\overline{\Delta}^{--}$.

In table 31.4, we have reported the different possible combinations of 2 dispirations of table 31.2, with their properties, by giving them a symbol and by calling them 'mesons' by analogy with the standard model.

combination	***symbol***	$\boldsymbol{\Omega}_{TL}$	$\boldsymbol{q}_{\lambda TL}$	***edge loop***	$\boldsymbol{q}_{\theta EL}$
$d\,\overline{d}$	π^0, ρ^0	0	0	-	0
$d\,\overline{u}$	π^-, ρ^-	$+3\pi/2$	$-3\pi^2 R_{TL}^2/2$	-	0
$\overline{d}\,u$	π^+, ρ^+	$-3\pi/2$	$+3\pi^2 R_{TL}^2/2$	-	0
$u\,\overline{u}$	η^0, ω^0	0	0	-	0

Table 31.4 - *The white mesons formed by 2 dispirations*

In this table, the analogy with the mesons of the standard model, composed of doublets of *quarks* u or d with anti-quarks $\overline{u}$ or $\overline{d}$, is obvious and perfect! We see particles composed of quarks (with fractional charges of rotation $\boldsymbol{q}_{\lambda TL}$) which correspond to the mesons of the standard model, but with a null charge of curvature by flexion $\boldsymbol{q}_{\theta EL}$, which implies that the topological singularities cannot be tagged as anti-matter (singularities of vacancy type) or of matter (singularity of interstitial nature)!

The fact that the particles of the standard model appear with two different symbols in the table is explained also by the notion of spin of the twist loop developed in chapter 29. Indeed, if each quark possesses a spin $\pm 1/2$, then the composition of spins can create global null spin in the case of particles π^0, π^-, π^+ *and* η^0, or a spin ± 1 in the case of particles ρ^0, ρ^-, ρ^+ and ω^0.

On the strong force and its asymptotic behavior

The quarks composing the particles of table 31.3 and 31.4 are linked by the cylinder of stacking faults, so that the energy of the topological singularity grows as $E_\gamma \sim \gamma_0 2\pi R_{TL} d$ if the distance d separating two dispirations grows. The force linking the dispirations is thus of “asymptotic nature”: it is a strong force in the s*ense that the linking force grows if we try to separate dispirations*. It is a phenomenon similar to the case of the energy of stacking faults between two partial dislocations in an *FCC* lattice (see fig. 9.9), or in the case of the energy of fault of mapping between 3 dislocations in an axial cubic lattice (see fig. 9.33). The equilibrium distance d between the dispirations is thus controlled by a competitive mechanism similar to those described in figures 9.9 et 9.33.

On the strong interaction between quarks via gauge bosons, the gluons

In the standard model, the quantum treatment of ‘colors’ of the quarks is done in Quantum Chromo Dynamics (QCD). In that theory, there exist 8 bosons with color gauges, vectors of the strong force, called *gluons.*

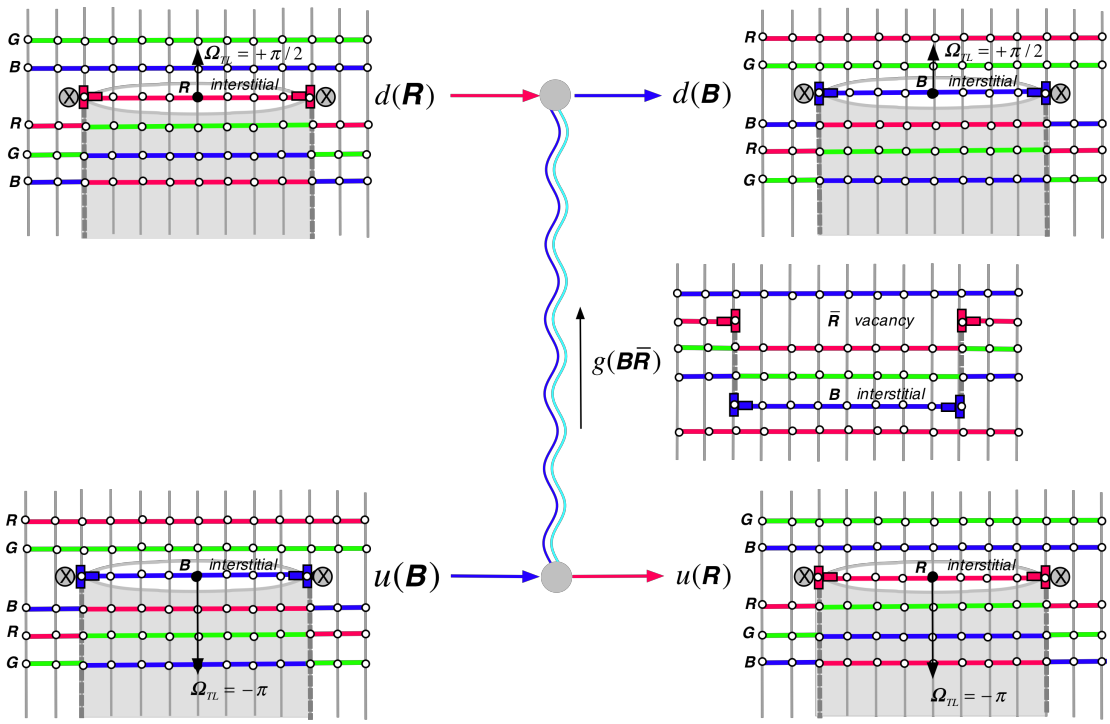


Figure 31.5 - *Feynman diagram of the exchange of colors of two quarks by the exchange of a bicolor gluon*

It is the exchange of a colored gluon between two quarks that makes these quarks change color, by an interaction that can be represented by a Feynman diagram (fig. 31.5) illustrated by the configuration of the topological singularities concerned.

The colored gluons correspond then to two edge dislocation loops, one of interstitial nature and one of vacancy nature and their charges of rotation $\boldsymbol{q}_{\lambda EL}$ is null. The edge loops are linked to

each other by the existence of a cylinder of stacking faults and are therefore submitted to the strong force. With respect to their curvature charge $\boldsymbol{q}_{\theta EL}$, it is null since we have $\boldsymbol{q}_{\theta EL} = (+2\pi a) + (-2\pi a)$, so that the *energy associated with the distortions of this pair of loops must be really weak*, and that, as a consequence, *the mass of gluons must be almost null, while it possesses a non null energy coming from the cylinder of stacking faults!* From this standpoint, the gluons are like photons.

In QCD, we think that it is this mechanism of exchange of gluons between neutrons and protons of the atomic core which explains the coherence of atoms. We are looking at a secondary effect of the strong force since the exchange of colored gluons perturb distances d between the dispirations composing neutrons and protons, with the consequence that they perturb the energies of protons and neutrons.

On the constitution of leptons and intermediary bosons of the standard model

In the standard model, there also exists a first family of quasi-punctual particles, which we call leptons and which are represented by the electron e^- , the anti-electron or positron e^+ , the electronic neutrino ν_e and the electronic anti-neutrino $\overline{\nu}_e$.

In the cosmic lattice, we already had postulated the existence of a neutrino in the form of an edge loop of interstitial nature, while the anti-neutrino would be an edge loop of vacancy type. It is actually what allowed us to deduce the gravitational properties for the neutrino, which are quite remarkable. These are due to a curvature charge of flexion which dominates the attractive gravitational effects due to its inertial mass. In the case of a 'colored cosmic lattice" as in figure 31.1, to respect the 3 rules that the lattice must abide by, the neutrino can only correspond to the insertion of 3 consecutive planes of color ***R***, ***G***, ***B,*** and the anti-neutrino to the subtraction of 3 consecutive planes $\overline{\boldsymbol{R}}$, $\overline{\boldsymbol{G}}$, $\overline{\boldsymbol{B}}$ (fig. 31.6, a and b), so as to form an interstitial or vacancy which has no color (white). Under this form, the neutrinos and anti-neutrinos have exactly the properties that we have deduced in the previous chapters for the edge loops, under the condition that their Burgers vectors have a norm such that $\left|\vec{B}_{EL}\right| = 3a$, so that the curvature charge due to flexion has a norm equal to $\left|\boldsymbol{q}_{\theta EL}\right| = 6\pi a$.

With respect to the electron and anti-electron, we already have emitted the hypothesis, that the twist disclination loop is a good candidate to represent them. In that case, to insure that the charges of rotation do correspond, it is necessary that the angle of rotation $\boldsymbol{\Omega}_{TL}$ between two consecutive planes be equal to $\pm 3\pi / 2$, so that the norm of its rotation charge satisfies the relation $\left|\boldsymbol{q}_{\lambda TL}\right| = 3\pi^2 R_{TL}^2 / 2$. However, under this pure form, the twist loop was already identified as the particle W^- or W^+ (fig. 31.2, e and f). Furthermore, the electron and positron must present an asymmetry between matter and anti-matter, and they must satisfy the weak leptonic interactions (fig. C.3,a). To satisfy these requirements, we must again use a combination of a twist loop with angle $\pm 3\pi / 2$, which satisfies rule 3 and which does not possess color, with an edge loop which corresponds to the insertion of 3 consecutive planes of color ***R***, ***G***, ***B,*** or to the subtraction of 3 consecutive planes $\overline{\boldsymbol{R}}$, $\overline{\boldsymbol{G}}$, $\overline{\boldsymbol{B}}$. In principle, there should be 4 different electrons, with charges $\boldsymbol{q}_{\lambda TL} = \pm 3\pi^2 R_{TL}^2 / 2$ and $\boldsymbol{q}_{\theta EL} = \pm 6\pi a$. However, the simplest way (and less energetic) to create an electron and a positron would be to compress the assembly of quarks $d\,d\,d$ and $\overline{d}\,\overline{d}\,\overline{d}$, so as to collapse the 3 twist loops in one and collapse the 3 edge

loops in one. We obtain then the electrons and positrons represented in figure 31.6, c et d.

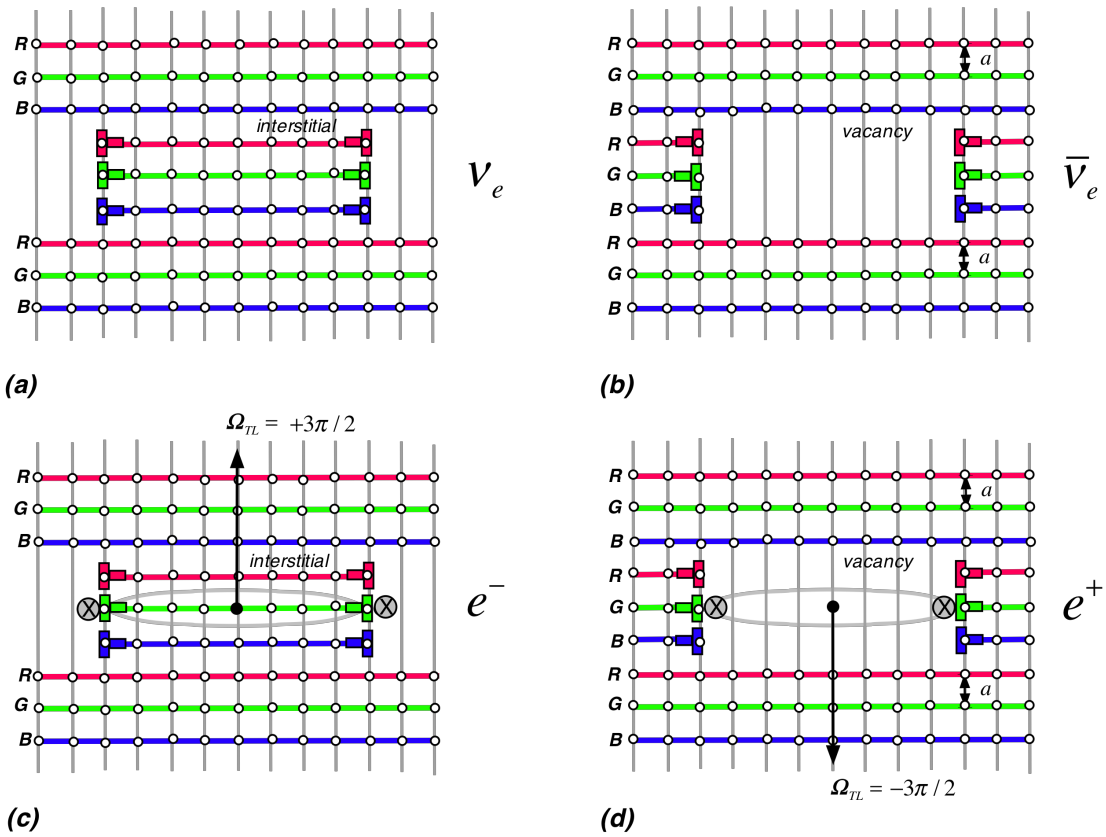


Figure 31.6 - *structure of the neutrino, the anti-neutrino, the electron and the positron, as combinations of edge dislocation loops and twist disclination loops*

On the weak interaction amongst leptons and intermediary bosons of the standard model

In the standard model, the weak interactions correspond to exchanging intermediary bosons $W^{\pm}$ or Z^0, which permits the exchange of electrical charge between the two particles (see fig. C.3). In order for the Feynman diagrams of figure C.3 to work with the dispirations of our model, it is necessary that the intermediary bosons be pure twist loops with angle of rotation Ω_{TL} respectively worth $\pm 3\pi/2$ ou 0, as represented in figure 31.2, e to g.

The intermediary bosons are then the only massive gauge bosons, which is readily understood if they are effectively pure twist loops. Experimentally we have found that their mass are much higher than that of the electron and positron, which could be understood by the fact that the rotation $\pm 3\pi/2$ must be done entirely on a distance a in the case of intermediary bosons, while in the case of electron and positron the rotation of $\pm 3\pi/2$ can be spread out over 3 successive planes, and thus over a distance $3a$, which must diminish considerably the local distortions of the lattice, and thus the energy of the particle. This could also be the reason why a gauge boson associates very fast with 3 PDLs, interstitial or vacancy, to diminish its energy, which could explain perfectly the weak interactions of figure C.3!

One should also note that, in the standard model of particles, the gauge bosons W^+ and Z^0

are of spin 1, and thus that they do not satisfy the principle of exclusion, which means that two gauge bosons can occupy the same state, and thus can be superposed, which in fact create a twist loop with angle Ω_{TL} which is equal to $\pm 3\pi$. On the other hand, the electron and positron are spin 1/2 particles, which satisfy the Pauli exclusion principle. They therefore cannot occupy the same state, which means that we cannot superimpose them, which becomes naively true if we consider the loop structure of electrons and of positrons as shown in figure 31.5.
We can then report the properties of leptons and gauge bosons in table 31.5.

symbol	Ω_{TL}	$q_{\lambda TL}$	***edge loop***	$q_{\theta EL}$
ν_e	$+3\pi/2$	0	*interstitial*	$-6\pi a$
e^-	0	$-3\pi^2 R_{TL}^2/2$	*interstitial*	$-6\pi a$
$\bar{\nu}_e$	$-3\pi/2$	0	*vacancy*	$6\pi a$
e^+	-3π	$+3\pi^2 R_{TL}^2/2$	*vacancy*	$6\pi a$
W^-	$+3\pi/2$	$-3\pi^2 R_{TL}^2/2$	-	0
W^+	$-3\pi/2$	$+3\pi^2 R_{TL}^2/2$	-	0
Z^0	$(+3\pi/2)+(-3\pi/2)$	0	-	0

Table31.5 - *The leptons of the first family and the intermediary gauge bosons*

On a tentative explanation of the 3 families of quarks and leptons of the standard model

In the standard model (Appendix C), there exist not only quarks and leptons as we just described them but there exists two additional families of quarks and leptons (fig. C.1), which are separated mostly by the increasing masses when we go from one family to the next. We show in figure 31.7 the progression of masses for the elementary particles of the standard model, by giving a multiplicative factor for the masses, in the vertical and horizontal directions. We notice that the multiplication factors shown are really high when going from one family to the other, while the multiplication factors to go from one particle to the next in each family are not that high, except in the case of the passage from neutrino to electron, which would indicate that the topological structure responsible for the large increase in mass changes from one family to the other but remains the same within the same family. It is also remarkable that the multiplying

factors associated with neutrino ν_e are a lot more high than all the other factors, which would indicate that it is the structures of the edge dislocation loops which change from one family to the other.

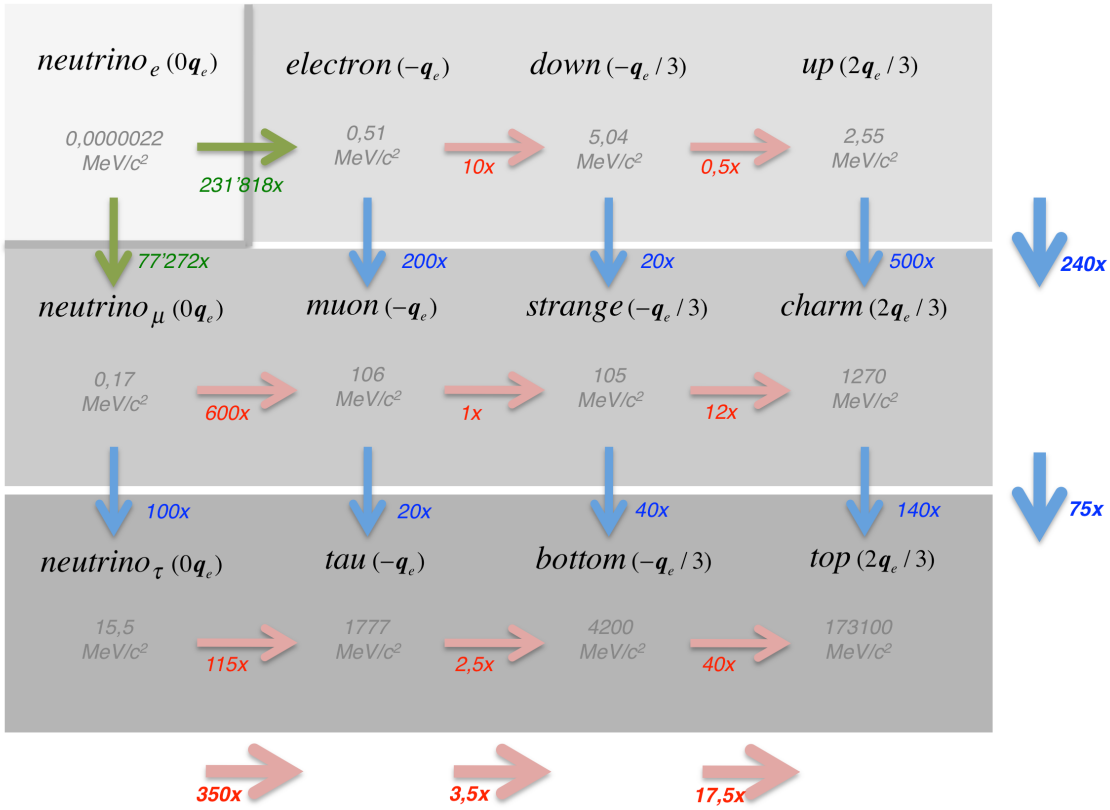


Figure 31.7 - *Masses of the particles of the standard model, as experimentally measured and expressed in MeV/c², with the multiplying factors*

With respect to the very large multiplicative factor to go from neutrino ν_e to electron e^-, it can be explained by the large difference between an edge loop and a twist loop, as we explained in section 19.11 by relation *(19.118).*

On the possibility to use edge disclination loops

If it is the structure of the edge parts of the topological singularity which must present changes from across families of leptons and quarks and justify such large energy variations from one family to the other, there exists within the theory of lattice singularities ideal candidates to fulfill these requirements: the edge disclination loops which were discussed in section 9.3, and notably the loops which could be realized with combinations of edge disclinations $C1$, $\bar{C}1$, $C2$ and $\bar{C}2$ (fig. 31.8).

Indeed, it is possible, by coupling two edge disclination loops $C1$ and $\bar{C}1$, or $C2$ and $\bar{C}2$, to form a topological structure which is complex and would correspond to an edge dislocation loop. The configuration of the two loops in relation to each other allows us to create pseudo loops of edge dislocations, either of vacancy or interstitial type, as shown in the two examples of figure 31.9 in the case of loops formed on the basis of disclinations $C1$ and $\bar{C}1$, represented here by

additional planes.

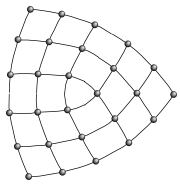
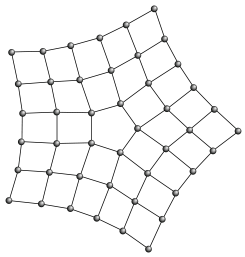
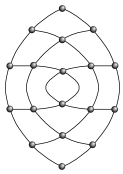
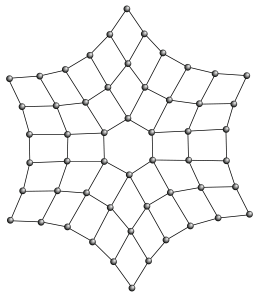
$C1 : \Omega = +90° : \Theta = -\pi / 2$	$\bar{C}1 : \Omega = -90° : \Theta = +\pi / 2$
	
$C2 : \Omega = +180° : \Theta = -\pi$	$\bar{C}2 : \Omega = -180° : \Theta = +\pi$
	

Tableau 31.8 - *Family of quantized edge disclinations in a cubic lattice*

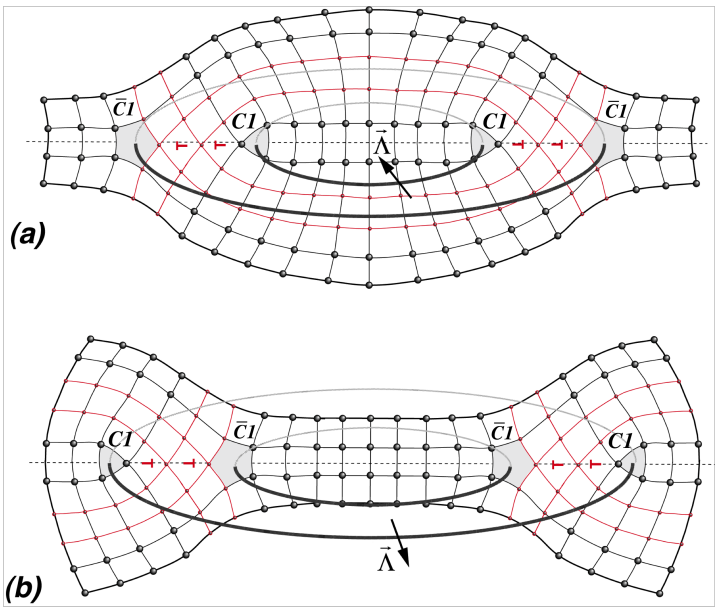


Figure 31.9 - *Formation of a loop and an anti-loop of type* $[C1, \bar{C}1]$

Even if the energy of the field of the edge dislocation is very small in the perfect lattice, the energy of a singularity made with disclination loops must be a lot higher, because resulting from very large distortions of rotation and shear in the lattice in the immediate vicinity of the loops!

On the construction of 3 families of quarks

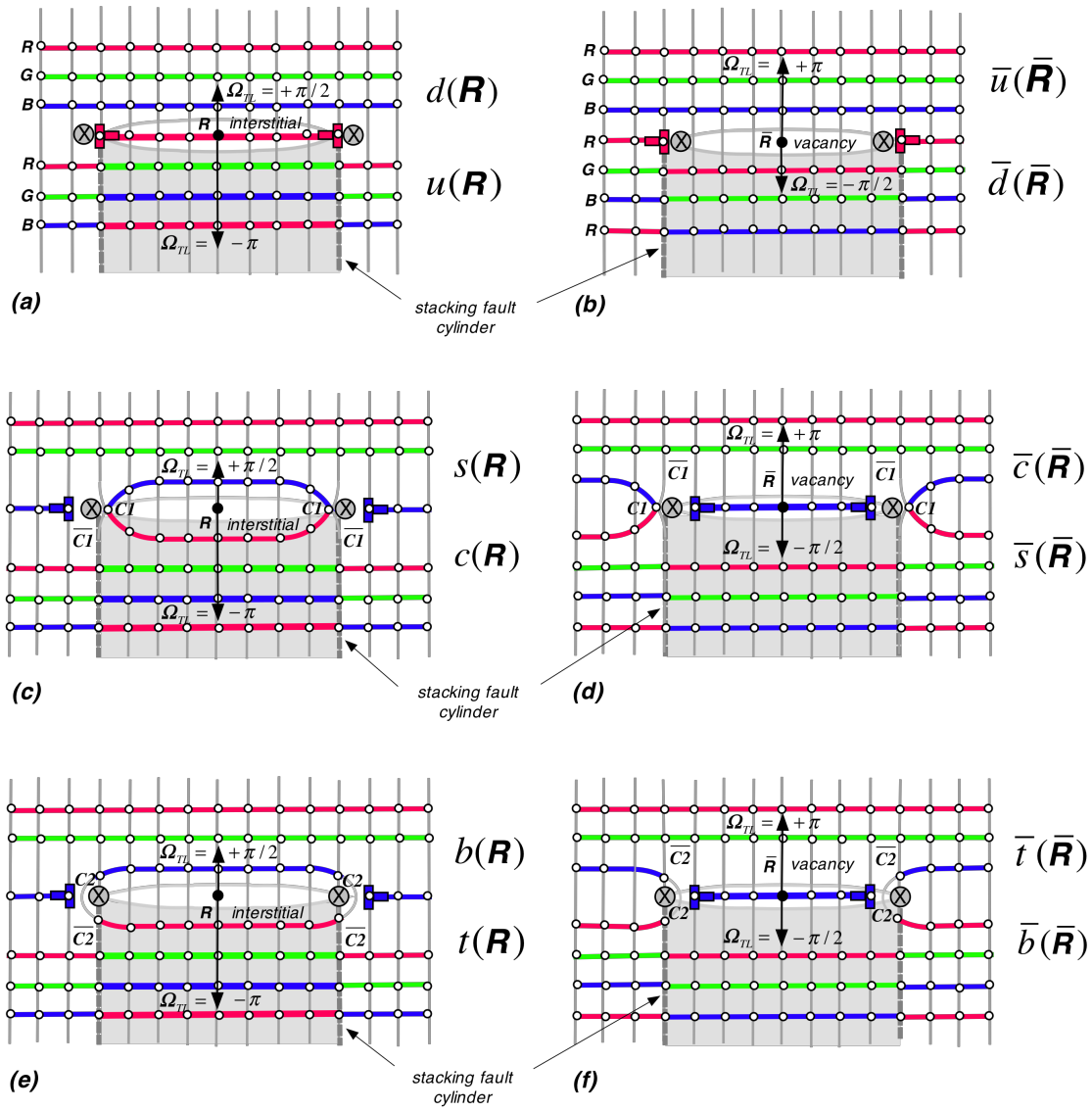


Figure 31.10 *- Structure of quarks as combinations of twist disclination loops, edge dislocation loops and pairs of edge disclination loops.*

In figure 31.10, we have shown the possible topological structures that could explain the quark families on the basis of the introduction of a pair of edge disclinations $C1$ and $\overline{C1}$ for the second family of quarks and a pair of edge disclinations $C2$ and $\overline{C2}$ for the third family of quarks. It should be noted that the structure of quarks is shown very schematically in this figure, since we have not reported the great distortions of the lattice implied by the presence of pairs of edge disclination loops. And it is precisely the much larger topological distortions of loops $C2$ and $\overline{C2}$ when compared to the loops $C1$ and $\overline{C1}$ which could explain the energy differences observed between particles of the second and third family. With respect to the first family of quarks, it does not contain any edge disclinations, which would explain the energy differences of particles in the first and second family of quarks.

With this explanation for the quark family, the gauge bosons $W^{\pm}$ and Z^{0} described in figure 31.2 are not modified since they do not involve edge dislocations! Furthermore, all the mechanisms described for the first family remain valid with the 3 quark families describe in figure 31.10, be it the weak hadronic interactions (fig. C.3) which involve gauge bosons $W^{\pm}$ as that reported by figure 31.3 or the *strong interactions* involving the bicolor gluons of figure 31.5 !

On the possible realization of 3 families of leptons

The pair of edge disclanation loops $C1$ and $\overline{C1}$, or $C2$ and $\overline{C2}$, can also be used to explain the 3 families of leptons which are observed in the standard model.
We have reported in figure 31.11 the topological structure of the 3 families of leptons based on the introduction of the pair of loops $C1$ and $\overline{C1}$, or $C2$ and $\overline{C2}$.

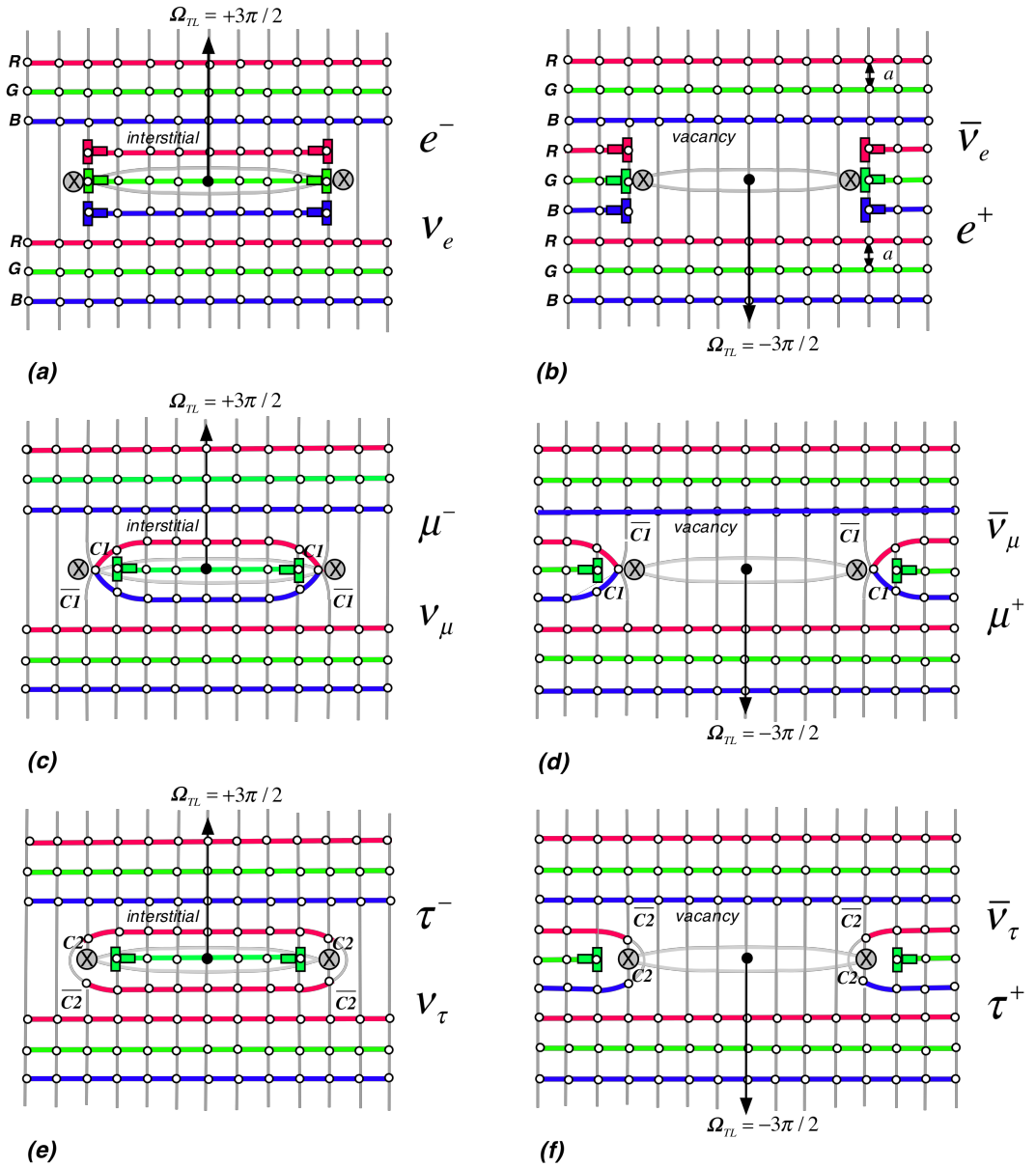


Figure 31.11 - *Structure of leptons, as assemblies of edge dislocation loops and pairs of edge disclination loops as well as twist disclination loops*

As in the case of the quarks of figure 31.10, the structures presented in figure 31.11, as well as all to topological structures reported in figures 31.2 to 31.9, strictly respect the rules of colors introduced in the beginning of the chapter, notably rule 1.
It is also easy to verify that all leptons of figure 31.11 will satisfy the weak leptonic and semi-leptonic interactions reported in figure C.3. Furthermore as there exist no cylinders of stacking faults in the structure of leptons, these leptons are not submitted to the strong force!

On the interest of the analogy between colored cosmic lattice and the standard model of particles

The analogy of our model, the colored cosmic lattice with its topological singularities, with the standard model of particles is excellent, and it is rich in explanations to many mysterious aspects of the standard model that we will enumerate here.

On the structure of particles of the standard model in 3 families of quarks and leptons

The topological structures of the edge dislocation loops, of the twist disclination loops and of the pairs of edge disclination loops that we introduced in the colored cubic lattice and which possess strict stacking rules and rotation rules of the colored planes, allow us to build all the particles of the standard model of particle physics, namely the quarks and leptons, which present a structure in 3 families for which the masses are very different. These different masses can be explained by the elastic energy of distortion of the lattice in the immediate vicinity of the loops. These diverse quarks and leptons also satisfy all the properties of the weak interaction and the strong interaction using respectively the intermediary gauge bosons $W^{\pm}$ and Z^{0} and the gluons, which possess also their own topological structure in the colored cosmic lattice. With respect to the strong force, it possesses all the good asymptotic properties due to the fact that it is generated by a cylinder of stacking faults whose energy increases if it is elongated, and is responsible for the existence of baryons and mesons, which are the only local topological structures which is 'non-colored' that one can form on the basis of quarks! In this fashion, we can reconstruct all the particles of the standard model, as for example the baryons and mesons of figures C.4 et C.5, composed of quarks and anti-quarks u, d, s and or c.

On the fields of interaction by weak force and strong force

With respect to the field forces acting on topological loops, they have simple topological explanations:
- the *weak force* is essentially due to the diminution of energy of formation of a dispiration loop when we associate an edge loop with a twist loop as was seen in section 25.3. The short range of the interaction potential of this force (attractive) explains the radio-active disintegration of elementary particles, by overcoming the interaction potential via a QM tunnel effect.
There exists gauge bosons that are exchanged during the weak interaction: these are the intermediary bosons $W^{\pm}$ and Z^{0}, which have a well defined topological structure, reported in figure 31.2.
- the *strong force*, which links 2 or 3 quarks together, is due to a cylinder of stacking faults, generated by the fact that the twist disclination loops associated with the quarks have a charge

$q_{\lambda TL}$ which are nothing else than the 1/3 or 2/3 of the charge of the twist loop associated with the electron. The dissociation distance between a doublet or a triplet of quarks depends essentially on the energy of stacking faults per unit of surface. If this energy is really strong, we can imagine that the loops are very close to each other as we have illustrated in the figures of this chapter. But if this energy if very weak, we could imagine fault tubes made of membranes whose diameter (equal to the diameter of the topological loops) is a lot smaller than the length, so that the topological singularities of doublet and triplets could look like *«long strings»* terminated at each extremity by topological loops!
There exists gauge bosons exchanged during the strong interaction: they are the bicolor gluons, which have a well defined topological structure, reported in figure 31.5.

On the possibility of calculating the energy of particles of the standard model

A first interesting consequence of this explanation of the particles of the standard model is linked to the fact that, in the case of dispiration loops and their interactions via the weak force and the strong force, the energies involved for the *formation* of multiplets of loops has a known origin, since it is the sum of the following energies:
(i) The formation energies associated with the strong local distortions of the lattice generated by the singularities and stored in the vicinity of the objects,
(ii) the connection faults which appear here because the lattice we imagined is a 'colored' one, linked to the fact that it should possess axial properties,
(iii) the energies involved in the *weak force* in the gravitational couplings between edge loops and twist loops as described in section 25.3,
(iv) the energies stored over longer distances, which are due to the long range distortions of the lattice linked to a global charge q_θ of curvature by flexion and the global charge q_λ of torsion by rotation of multiple loops, which are contained in the calculations of formation energies, of gravitation and of curvature charges as we have done in the previous chapters, as well as the self vibrational energies and self rotational energies as we have seen in chapters 28 and 29 respectively.
The total energy of formation of loop multiples can then be calculated in a rigorous fashion, on the condition of knowing the exact elastic properties (the modules K_0, K_1, K_2 and K_3) as well as the surface fault energy γ_0 of the cosmic lattice in which the objects appear. This energetic aspect is very important as, in the case of the standard model of particles, the origin and value of the energy of elementary particles (their mass) is still rather mysterious, and are introduced as parameters in the standard model, which are measured experimentally!
Furthermore, by observing the distortions of the lattice that are generated in the vicinity of the loops of different families, we can imagine that the progression of energy of multiple loops as a function of their 'family order number' must be largely non-linear, a phenomenon which is observed in the case of the energies of leptons and quarks of the different families of the standard model.

On the elementary nature of the particles of the standard model

Another interesting consequence of our conception of the standard model is that there is a dif-

ferent 'elementarity' to the topological loops of dispiration of our lattice as opposed to the leptons and quarks of the standard model. These are not elementary particles but the assembly of more elementary constructs, namely the edge dislocation loops, of interstitial or vacancy types, the twist disclination loops and the 4 loops formed out of the edge disclinations $C1$, $\bar{C}1$, $C2$ and $\bar{C}2$ of figure 31.8 linked to each other in the form of pairs of loops by a strong force purely of topological nature, the ribbon of virtual dislocations linking the two edge disclination loops.
To judge the other potentials coming out of this idea of how particles of the standard model come about, it should be verified if this approach would allow us to justify and explain the complicated set of selection rules which had to be introduced in particle physics to describe all the interactions which are observed experimentally. This is only a suggestion and its detailed development is not included in this treatise. It should be noted that similar approaches to the decomposition of the particles of the standard model have already been proposed in particle physics, but under different forms, such as the model based on pre-quarks called *«rishons»*. However these models have proven to not be fruitful.

On the role of the curvature charge in the standard model

The curvature charge q_θ plays an important role in the building of a model of "elementary topological singularities" to explain the standard model of particles. We notice relatively easily that this charge, for which there is no analogy in the standard model, satisfies a conservation principle during the loop interactions, be them weak or strong.
The question is then to know if the charge q_θ, which is conserved during the interactions between loops, has a correlation with one of the characteristic values or with one of the conservations relations of the standard model (such as the Gell-Mann-Nishijima relation for example). The answer to this question could assuredly give us strong hints for particle physics, as we have repeatedly shown that *it is the curvature charge* q_θ *which is responsible for the asymmetry between matter and anti-matter,* and consequently responsible for the evolution of matter and anti-matter, as well as the presence of dark matter, in the form of a repulsive sea of neutrinos around galaxies!

On the open questions about the 'colored cosmic lattice' and its analogy with the standard model

The analogy developed in this chapter between topological dispiration loops in an imaginary cubic lattice and the standard model of particle physics is fruitful to understand many obscure points of particle physics, such as the topological nature of elementary particles, as well as the weak and strong forces, or the origin of mass in elementary particles.
However there exist many open questions, which merit to be studied in detail, amongst which the main ones are:

On the application of the concept of spin

As we have shown in chapter 29, the notion of spin seems to correspond to a real rotation of topological loops. But there are many questions which would warrant further study.

The first question is naturally to try and imagine how an edge dislocation loop and a twist disclination loop or an edge disclination loop can turn on themselves in a cubic cosmic lattice, knowing that additionally we need a tube of stacking faults to explain the strong force in the case of baryons and mesons. Is there a topological explanation for such a rotational movement, or should we imagine a lattice with even weirder properties?
The second question is linked to the value that one should assign to the spin of the topological loop. For example, why does the electron, which corresponds to a perfect coupling between a twist disclination loop and an edge dislocation loop, have a spin 1/2, while the gauge boson $W^{\pm}$, which would correspond to an isolated twist disclination loop, have a spin 1? Does there exist a topological reason for a given loop to possess a 1/2 or a spin 1, or should we again, invoke 'strange properties' of the colored cosmic lattice?
The third question would be to know how to apply more carefully the concept of spin developed in chapter 29 to the colored cosmic model that we have described in this chapter. The response to this question could allow us to find an explanation to the existence of particles composed of the same quarks, but with different spins, such as mesons π^+ and ρ^+ each composed of quarks $u\bar{d}$, but with respective spins 0 and 1, or the baryons p (proton) and Δ^+ which are both composed of quarks uud, but with respective spins worth 1/2 and 3/2. Such a study could also allow to explain the exact origin of spin 1/2 of baryons and of spin 1 of mesons, which is still a rather obscure point of the standard model of particles, but which remains just as obscure in our theory of a 'colored' lattice!

On the QCD theory

It should be instructive and interesting to study more in depth the wave equations, the concepts of *bosons and fermions*, the *Pauli exclusion principle* developed in chapter 28, as well as the spin notion introduced in chapter 29, as well as the topological loop singularities which reconstruct the standard model, and see if such a study would not lead us eventually to a comprehensible physical explanation of QCD?

On the existence of supersymmetric models

A more in-depth study could not only explain why there exists *fermions* in the standard model (particles with spin 1/2 as quarks and leptons) and *bosons* (particles with spin 1 like the intermediary gauge bosons and the gluons), but it could also answer the question of knowing if it would be possible to create a zoology of particles identical to those that we have obtained in this chapter, but for which we would have inverted spins 1/2 and 1, which would give rise to a 'supersymmetric model'!

On the existence of a fourth family of quarks and leptons

When we introduced the edge disclinations $\boldsymbol{C1}$, $\boldsymbol{\bar{C}1}$, $\boldsymbol{C2}$ and $\boldsymbol{\bar{C}2}$ to explain the families of the standard model, we have consciously neglected the existence of loops of edge disclination $\boldsymbol{C3}$ and $\boldsymbol{\bar{C}3}$ reported in figure 9.20. If these disclinations could really exist in a colored cosmic lattice, there would be a *fourth family of quarks and leptons*, whose energy would then be humongous!

On the existence of «exotic leptons»

In our description of quarks of figure 31.10, the fact that quarks possess electric charges -1/3 and +2/3 of the charge of the electron, while the anti-quarks possess an electrical charge +1/3 and -2/3 of the electron charge, is easily explained by the hypothetic *rules of succession of the colors in the particulate planes*. However, for the leptons which we have introduce in figure 31.11, we have now chosen *arbitrarily* to associate to the neutrino an electrical charge -1 to obtain the *electron of matter* and to associate to the anti-neutrino an electrical charge +1 to obtain the anti-matter positron. However the rules about color that we have introduced would not prevent us from associating a charge +1 to the neutrino to obtain *an exotic positron of matter* and an electrical charge -1 to the anti-neutrino to obtain an exotic electron of antimatter. There is here another subject of reflexion. Indeed:

- either the *exotic leptons do not exist*, in which case one should surely find a more convincing explanation than the one we have proposed to explain that the electron be made of matter and the positron of anti-matter (we have proposed that the electron and the positron could be considered as the results of compression of assemblies of quarks $d\,d\,d$ and $\overline{d}\,\overline{d}\,\overline{d}$, which would explain the existence of electrons of matter and positrons of anti-matter and the absence of electrons of anti-matter and the positrons of matter),

- either the *exotic leptons do exist*, in which case one should explain why these particles have never been observed experimentally!