Chapter 9

Cohesion of the edge-screw dispirations and the weak force

Considering topological singularities formed from the coupling of a twist disclination loop with an edge dislocation loop, which are called *dispiration loops*, *an interaction force similar to a capture potential* appears, *with a very small range*, which induces interactions between loops presenting *a perfect analogy with the "weak interactions"* between elementary particles of the Standard Model.

Previously, the notion of *"mass of curvature"* of the edge dislocation loops appeared, which corresponds to the equivalent mass associated with the gravitational effects of the charge of curvature of these loops, and which can be positive in the case of loops of vacancy nature or negative in the case of loops of interstitial nature. In fact, the charge of curvature and the mass of curvature associated with the edge dislocation loops do not appear in any other physical theory, nor in General Relativity, nor in Quantum Physics, nor in the Standard Model of elementary particles. But in our approach, it is precisely this mass of curvature which becomes responsible for the appearance of *a weak asymmetry between the particles* (hypothetically containing edge loops of interstitial nature) *and the anti-particles* (hypothetically containing edge loops of vacancy nature), and this weak asymmetry between matter and antimatter will be called upon to play a capital role in the cosmological evolution of topological singularities described in the following chapter.

While the previous chapter presented all of the long-range "gravitational" interactions between the various topological singularities of the cosmological lattice, this chapter is concerned with *the very short-range "gravitational" interaction* that occurs between a twist disclination loop *(BV)* and an edge dislocation loop (BC) due to the expansion perturbations associated with the curvature charge of the edge loop and the short-range perturbations associated with the rotation charge of the twist loop .

It is explained that this interaction between rotation and curvature charges corresponds to *a very short-range repelling force in* $1/d^5$ when the two loops are separated, but that it corresponds to *a cohesive force* when the two loops are joined in the form of a dispiration.

Long-range and short-range interactions between a twist disclination loop (BV) and an edge dislocation loop (BC)

If a twist disclination loop of radius R_{BV} is close enough to an edge dislocation loop of radius R_{BC}, as shown in figure 9.1, the total interaction energy between the two loops will involve the energies associated with the gravitational fields at long range, but also an interaction energy linked to *the short-range expansion perturbation field of the twist disclination loop*. By expressing the fields of long-range in $1/r$ and short-range in $1/r^4$ of the twist disclination loop (figure 7.10), the distortion energy of the edge dislocation loop can be calculated (figure

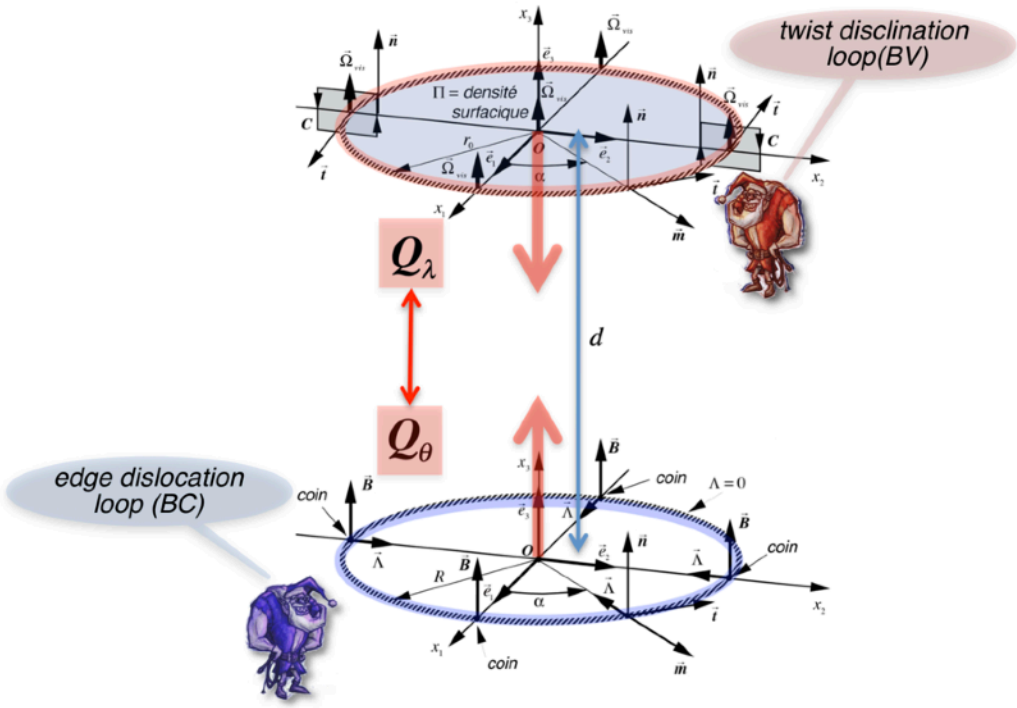

Figure 9.1 *- Long and short range interactions between a loop of twist disclination (BV) and a loop of edge dislocation (BC)*

8.8), and likewise by calculating the long-range field in $1/r$ of the edge dislocation loop (figure 7.11), the distortion energy of the screw loop can also be calculated (figure 8.8), so that the total gravitational interaction energy between the two loops is written as the sum of these distortion energies. Taking into account that the mass of curvature of the edge loop is much greater than its mass of inertia $\left|M^{BC}_{curvature}\right| >> M^{BC}_{0}$, the total energy of the two loops can be simplified, and we can then find the increase ΔE^{BV-BC}_{inter} in energy compared to the sum of the energies of the two loops when they do not interact, corresponding to the interaction energy of the two loops. After some calculations, we obtain the relation for this increase ΔE^{BV-BC}_{inter} as expressed in figure 9.2.

At long distance, it is the term in $1/d^4$ which prevails, so that the interaction energy is negative if $M^{BC}_{curvature} > 0$, that is to say if the edge loop is of vacancy nature, and it is positive if $M^{BC}_{curvature} < 0$, that is to say if the corner loop is of interstitial nature (figure 9.2).

At a short distance, this is the term in $1/d^4$ that prevails, so that the energy of interaction necessarily becomes positive (figure 9.2). In the case of the vacancy type edge loop, we have $M^{BC}_{curvature} > 0$, so that the interaction energy goes through zero for $d = d_0$ whose value is given in figure 9.2

From the energy increase ΔE^{BV-BC}_{inter}, we can deduce the "gravitational" force of interaction $\boldsymbol{F}^{BV-BC}_{grav}(d) = \partial \boldsymbol{E}^{BV-BC}_{inter} / \partial d$ between the two loops thanks to the derivative with respect to the distance d. The expression of this force is also reported in figure 9.2, and we note that at long distance, it is the term in $1/d^2$ which prevails, so that the interaction force is negative, therefore repulsive, if $M^{BC}_{curvature} < 0$, that is to say if the edge loop is of interstitial nature, and it is positive,

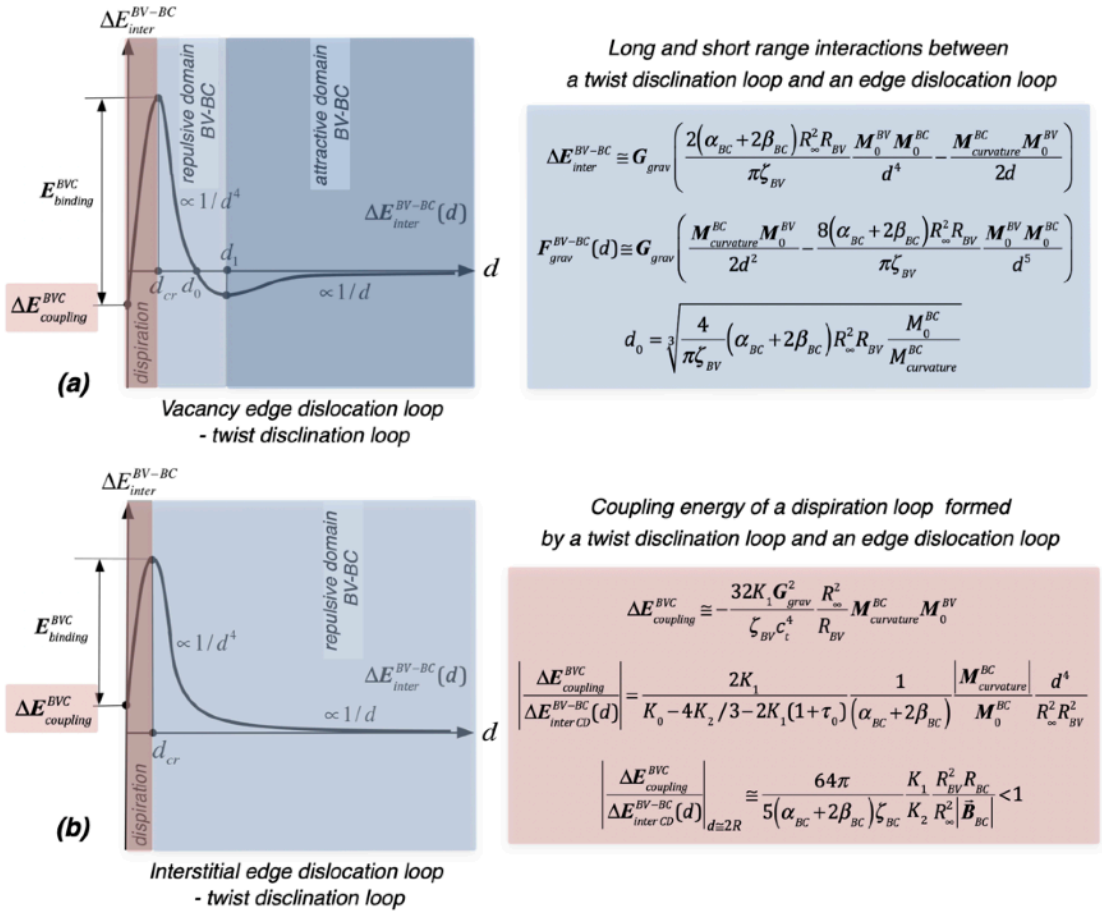

Figure 9.2 - *Interaction (capture) potential between an edge dislocation loop BC, of vacancy type* **(a)** *or interstitial type* **(b)** *and a twist disclination loop BV to form an edge-screw dispiration loop BCV*

therefore attractive, if $M^{BC}_{curvature} > 0$, that is to say if the edge loop is of vacancy nature.

At a short distance, this is the term in $1/d^5$ which prevails, so that the force of interaction becomes necessarily negative, therefore repulsive. In the case of the vacancy type edge dislocation loop for which $M^{BC}_{curvature} > 0$, the interaction force goes through zero for $d_1 = d_0 \sqrt[3]{4}$ and it presents a maximum for $d_2 = d_1 \sqrt[3]{10}$.

Coupling energy of a screw-edge dispiration loop (BVC) formed by a twist disclination loop (BV) and an edge dislocation loop (BC)

If a twist disclination loop *(BV)* of radius R_{BV} combines with an edge dislocation loop *(BC)* of radius $R_{BC} = R_{BV}$, we obtain *a screw-edge dispiration loop (BVC)*. The elastic energy and the kinetic energy of this loop of dispiration is due to the field of rotation of the twist loop, to the fields of expansion and of shear of the edge loop and to the field of speed due to the two loops. As the various fields of the two loops are all orthogonal and contained in the torus surrounding the *screw-edge dispiration loop*, the relativistic energy of this one is the sum of the relativistic energies of the two loops, and is simply worth $E^{BVC}_{\boldsymbol{v}} = \left(M^{BV}_0 + M^{BC}_0\right) c_t^2 / \gamma$.

On the other hand, if we consider the external field of expansion perturbations associated with this dispiration loop, we will have the short and long distance fields of the screw loop (figure 7.10) and the fields of the edge loop (figure 7.11) which will overlap on the outside of the dispiration. The “gravitational” energy of this perturbation field can be calculated, and we then obtain the individual energies of the perturbation fields of each of the loops, but there is added a new coupling term between the two loops, due to the terms of interaction between the twist loop and the edge loop which occur in the square term $\left(\tau^{BV}_{ext\ LD}(r)+\tau^{BV}_{ext\ CD}(r)+\tau^{BC}_{ext\ LD}(r)\right)^2$. These coupling terms contribute to an increase $\Delta E^{BVC}_{coupling}$ in energy which, taking into account the fact that $M^{BC}_0 << \left|M^{BC}_{curvature}\right|$ and keeping only the most important term, is represented by the value reported in figure 9.2.

In fact, this energy is due to the coupling of the external field of expansion perturbations at short range due to the rotation charge of the twist loop with the external field of expansion perturbations due to the charge of curvature of the edge loop. It is therefore an interaction between the rotation and curvature charges of the two loops of dispiration via their respective external gravitational effects. We also note that this coupling energy is negative if $M^{BC}_{curvature} > 0$, that is to say if the edge loop is of lacunar type, and positive if $M^{BC}_{curvature} < 0$, that is to say if the edge loop is of interstitial type.

We can now compare the energy $\Delta E^{BV-BC}_{inter\ CD}(d)$ of gravitational interaction at short distance between two loops distant of d with the energy $\Delta E^{DCV}_{couplage}$ of coupling within the loop of dispiration. It comes the relation for $\left|\Delta E^{BVC}_{coupling} / \Delta E^{BV-BC}_{inter\ CD}(d)\right|$ reported in figure 9.3. For a distance of the order of $d \approx 2R_{BV}$, we therefore have, if $\tau_0 << \tau_{0cr}$, and remembering that $K_3 = K_0$ in the perfect cosmological lattice that $\left|\Delta E^{BVC}_{coupling} / \Delta E^{BV-BC}_{inter\ CD}(d)\right|_{d \cong 2R} < 1$. Indeed, in the expression of figure 9.2, it appears the relation $R^2_{BV} R_{BC} / R^2_{\infty} \left|\boldsymbol{B}_{BC}\right|$ which is very likely to be much smaller than the unit, so that the absolute value $\left|\Delta E^{BVC}_{coupling}\right|$ of the energy of coupling of the dispiration is undoubtedly clearly smaller than the interaction energy ΔE^{BV-BC}_{inter} between the two loops when separated by a distance $d \approx 2R_{BV}$.

It is deduced therefrom that *the potential energy of interaction* ΔE^{BV-BC}_{inter} between the two loops, as a function of the distance d between these two loops behaves in fact like *a capture potential* such as that represented in figure 9.2 in the domain “dispiration”. This potential keeps the two loops linked within the dispiration, with a binding energy $E^{BVC}_{binding}$ corresponding to the energy difference between the maximum of the potential energy ΔE^{BV-BC}_{inter} of interaction of the separate screw and twist loops and the coupling energy $\Delta E^{BVC}_{coupling}$ of the dispiration.

The potential energy of interaction ΔE^{BV-BC}_{inter} represents a repulsive force in $1/d^5$ between the two loops as soon as they separate from a distance greater than a certain critical distance of the order of $d_{cr} \approx 2R_{BV}$. To separate the two loops from the dispiration, it suffices:
- either of *an energy fluctuation* equal to or greater than the binding energy $E^{BVC}_{binding}$ of the dispiration loop, so that the two individual loops meet at a distance $d > d_{cr}$ and repel each other definitively,
- either that the edge loop crosses the potential barrier by *quantum tunnel effect*, and that the individual loops are found at a distance $d > d_{cr}$ and repel each other definitively.

About the analogy with the weak interaction of Standard Model of elementary particles

The short-range interaction that we have just described between the rotation and curvature

charges, respectively of a twist diclination loop and an edge dislocation loop, presents a remarkable analogy with *the weak interaction of the Standard Model of elementary particles*.

One of the four fundamental forces of nature is the weak interaction of the Standard Model. It is responsible for the radioactive decay of elementary particles and it affects all fermions, namely electrons, neutrinos and quarks. In the Standard Model, the weak interaction is linked to the exchange of massive bosons $\overline{W}^{+}$, W^{-} and Z^{0}, and it explains the weak lepton, semi-lepton and hadronic interactions. It is because this interaction is very short-range and weaker than the strong interaction and the electromagnetic interaction that it has been described as a weak interaction. On the other hand, it also has the property of breaking the ***P*** parity symmetry and the ***CP*** symmetry. It is also directly linked to the electric charge since electromagnetic interactions and weak interactions, which could be unified as two aspects of *an electroweak interaction.*

The analogy between the short-range interaction between an edge loop and a twist loop and the weak interaction of the Standard Model is literally obvious. Indeed:

- both are responsible for a weak bond within particles or loops,
- the two interactions have a very weak range,
- they both allow the decomposition of a particle or a loop into other particles or other loops,
- the decomposition of a particle or a loop of dispiration can be obtained by a local fluctuation of energy, or a quantum tunnel effect, which obviously intervenes in a random way, just like the radioactive decay associated with weak interaction is a statistical phenomenon,
- the weak interaction participates in the symmetry breaking ***P*** and ***CP***, which agrees with the fact that it has asymmetry of the interactions between a twist loop and a lacunar or interstitial edge loop (figure 9.2).

As an example, consider the weak decay transforming the muon μ^{-} into an electron e^{-} shown in figure 9.3. This weak leptonic interaction presents an initial decomposition of the muon μ^{-} into a muonic neutrino ν_{μ} and a massive boson W^{-}, then the decomposition of the massive boson W^{-} into an electron e^{-} and an electronic anti-neutrino $\overline{\nu}_{e}$.

Let us then consider conjecture 8 which stipulates that *"the singularities of a vacancy nature correspond by analogy to anti-matter and the singularities of interstitial nature to matter"*. On this basis, let us suppose for example that the combination of a twist disclination loop BV^{-} with an interstitial edge dislocation loop $BC_{(1)}^{(i)}$ in the form of a loop of dispiration is the analog of the electron e^{-}, and imagine that the combination of a twist disclination loop BV^{-} with an interstitial edge dislocation loop $BC_{(2)}^{(i)}$ of slightly different topology (see chapter 13) forms a dispiration loop analog of a muon μ^{-}. The weak decay causing the muon μ^{-} to transform into an electron e^{-} shown in figure 9.3 (a) would then have a similar decay of the loops shown in figure 9.3 (b). The initial dispiration corresponding to the muon μ^{-}, and made up of the couple $BV^{-}+BC_{(2)}^{(i)}$ linked by the weak force, is broken down into a twist disclination loop BV^{-} carrying the rotation charge, and analogous to the massive boson W^{-} carrying the electric charge, and into an interstitial edge dislocation loop $BC_{(2)}^{(i)}$ analog to the of muonic neutrino ν_{μ}. Next, the twist disclination loop BV^{-} combines with an interstitial edge dislocation loop $BC_{(1)}^{(i)}$ to form a dispiration $BV^{-}+BC_{(1)}^{(i)}$ *analog to* an electron e^{-}, by emitting a vacancy edge dislocation loop $BC_{(1)}^{(i)}$, analog to the electronic anti-neutrino $\overline{\nu}_{e}$.

The weak interaction corresponding to the transformation of the anti-muon $\overline{\mu}^{+}$ into a

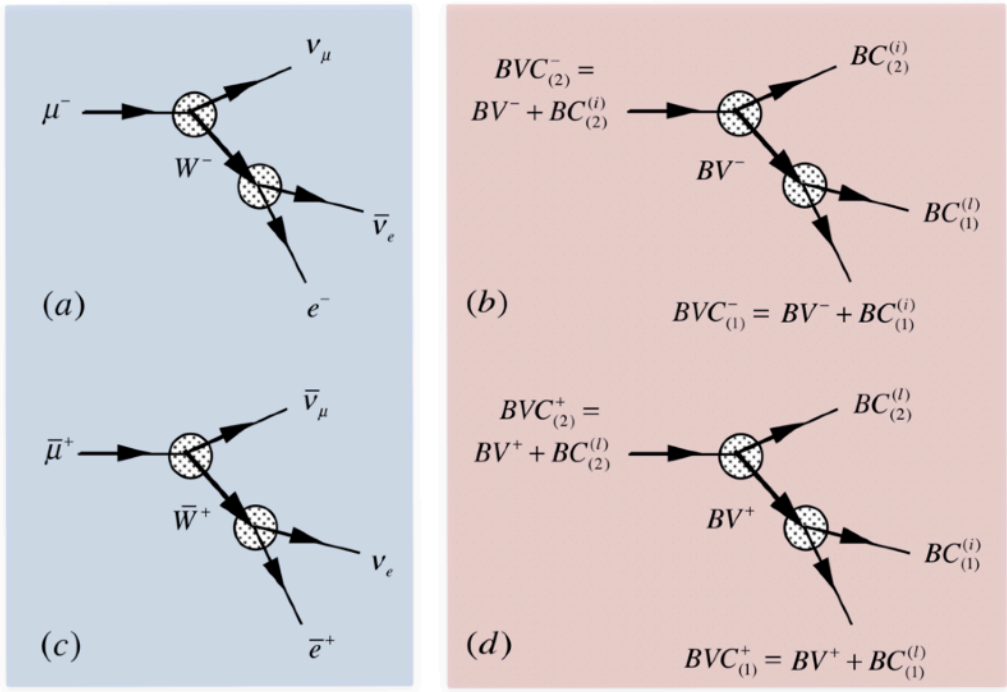

Figure 9.3 *- Analogy between the weak leptonic interaction* ***(a)*** *and* ***(c)*** *and the decompositions and recompositions of dispiration loops* ***(b)*** *and* ***(d)***

positron $\bar{e}^+$ shown in figure 9.3 (c) also has its perfect analogue with loops shown in figure 9.3 (d). But this time, the twist disclination loop is replaced by the anti-loop BV^+ with an opposed rotation charge and the vacancy type edge loops are replaced by interstitial edge loops and vice versa. If we now consider the interactions between loops in figures 9.3 (b) and 9.3 (d), we immediately imagine that there is an asymmetry between these two reactions due to the slightly different interaction potentials in the case of lacunar and interstitial loops (figure 9.2). This asymmetry then becomes the analog of the violation of parity symmetry ***P*** and of symmetry ***CP*** in the case of weak interactions. We will return in detail in chapter 13 on the topological structures of the twist disclination loops and of the edge dislocation loops which could be involved in weak interactions.