Chapter 12

Spin of the topological loops

In this chapter, we are going to be interested in finding the solution of Newton's second partial equation within the torus itself surrounding a twist disclination loop. At the very heart of a loop of topological singularity, one demonstrates that it cannot exist static solutions to Newton's second partial equation for longitudinal gravitational fluctuations. It therefore becomes imperative to find a dynamic solution to this equation, and the simplest dynamic solution that it is possible to envisage is that the loop turns on itself, in a quantified rotational movement of the loop around one of its axes. By solving this rotation movement with Newton's second partial equation, which is in this dynamic case nothing other than the Schrödinger's equation, one obtains the quantified solution of the internal gravitational fluctuations of the loop, which is in fact *the spin of the loop*, which can take several different values (1/2, 1, 3/2, etc.) and which is perfectly similar to the spin of the particles of the standard model. If the loop is composed of a twist disclination loop, there also appears *a magnetic moment of the loop*, proportional to the famous *Bohr magneton*.

On shows that, in the case of our approach, this rotation movement is very real, and that it does not infringe special relativity, contrary to what believed the pioneers of quantum physics. Indeed, the argument of the pioneers of quantum physics was that the spin of a particle can in no case be a real rotation of the particle on itself because of an equatorial speed of rotation greater than the speed of the light. This argument is swept away in our approach by the fact that the static expansion near the core of the loop is very high, which leads to celerities of light in the vicinity of the core of the loop much higher than the equatorial speed of loop rotation.

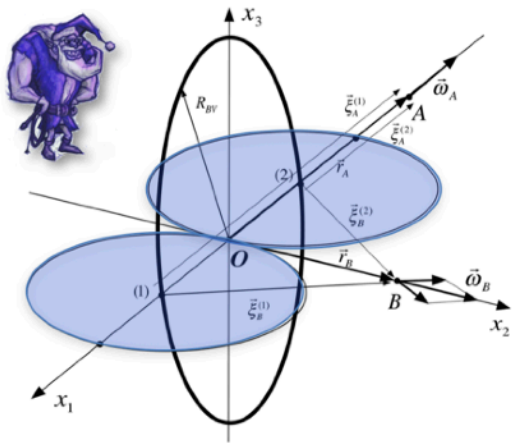
In this argument on the absolute necessity of a spin of singularity loops to satisfy Newton's second partial equation, only the exact value of the spin of a loop, namely the values 1/2 or 1, has no simple explanation yet.

About the non-existence of a static internal field of perturbations of expansion within a loop of twist disclination (BV)

We have already calculated the static external fields of gravitational perturbations of expansion of a twist disclination loop (figure 7.10), and we have seen that these fields are responsible for the effects of gravitational attraction at long distance from the loop via gravitation force (chapter 8), but also short-range coupling effects with other loops via the weak force (chapter 9).

On the other hand, we have not yet looked into the case of the expansionperturbation field in the immediate vicinity of the twist disclination loop. This field must be calculated within the torus surrounding the twist disclination loop. By using a simplified static version of Newton's second

partial equation of figure 5.1, in which one introduces the energy density $F_{dist}^{BV}(\vec{\xi})$ of distortion associated with the fields of rotation and shears of the screw pseudo-dislocation, one obtains an equation of the second degree whose solution $\tau_{int}^{BV}(\vec{\xi})$ within the torus is shown in figure 12.1, and in which $\vec{\xi}$ represents a point on a section of the torus relative to the center of this section.



Static solution

$$\tau_{int}^{BV}(\vec{\xi}) = \frac{4K_2/3 + 2K_1(1+\tau_0) - K_0}{2K_1}\left[-1 + \sqrt{1 - \frac{K_1(K_2+K_3)}{\left(4K_2/3 + 2K_1(1+\tau_0+) - K_0\right)^2}\frac{\boldsymbol{q}_{\lambda BV}^2}{2\pi^4 R_{BV}^2}\frac{1}{\xi^2}}\right]$$

Condition of existence of a static solution

$$\xi > \xi_{cr} = \sqrt{\frac{K_1(K_2+K_3)}{2\pi^4\left(4K_2/3 + 2K_1(1+\tau_0+) - K_0\right)^2}}\frac{|\boldsymbol{q}_{\lambda BV}|}{R_{BV}} \cong \frac{1}{\pi^2}\sqrt{\frac{K_1}{2K_0}}\frac{|\boldsymbol{q}_{\lambda BV}|}{R_{BV}}$$

Conjecture 11: K_1 *satisfies the following relationship in the perfect cosmological lattice*

$$K_1 > K_{1cr} = K_0\frac{2\pi^4 R_{BV}^2}{\boldsymbol{q}_{\lambda BV}^2} \quad \Rightarrow \quad \textit{no static solution possible}$$

Figure 12.1 *- Non-existence of static solutions for the internal gravitational perturbations of a twist disclination loop*

So that this equation has a real solution, it would be necessary that the argument of the root is positive, therefore that the distance $\vec{\xi}$ in the middle of the loop satisfies the condition of existence reported in figure 12.1, which means that the distance $|\vec{\xi}|$ must be greater than a certain critical value ξ_{cr} for a static solution to exist. If this critical distance turns out to be greater than the radius R_{BV} of the loop, it is clear that a static solution becomes impossible. It is quite easy then to show that the condition for which $\xi_{cr} > R_{BV}$ is in fact a condition on the value of the module K_1, which is expressed as $K_1 > K_{1cr} = 2\pi^4 K_0 R_{BV}^2 / \boldsymbol{q}_{\lambda BV}^2$, and which means that, if K_1 is greater than the critical value K_{1cr}, there cannot exist a static solution for gravitational perturbations within the torus surrounding the disclination loop.

It is interesting to involve here numerical values which one can draw from the real world, by using for example the analogy with the electrons, namely that, for these, one has an electric charge being worth $\left|\boldsymbol{q}_{\lambda BV}\right| = \boldsymbol{q}_{electron} = 1.6 \cdot 10^{-19}\left[C\right]$, an estimated radius of the order of $10^{-18}\left[m\right]$ and that the elastic moduli $K_3 = K_0$ are in fact the analogs of the dielectric constant of vacuum, so that $K_3 = K_0$, the condition $K_1 > K_{1cr}$ would then imply that $K_{1cr} = K_0 2\pi^4 R_{BV}^2 / q_{\lambda BV}^2 \cong 10^{-21}$.

The condition that the module K_1 is greater than the critical value $K_{1cr} \cong 10^{-21}$ is very likely to be fulfilled in the presence of a twist disclination loop, which is strongly supported by the numerical application obtained thanks to the analogy with the electrons of the real world. Let us therefore admit a new conjecture, conjecture 11, which states that K_1 satisfies well the relation $K_1 \geq K_{1cr} = K_0\ 2\pi^4\ R_{BV}^2 / \boldsymbol{q}_{\lambda BV}^2$ in the perfect cosmological lattice.

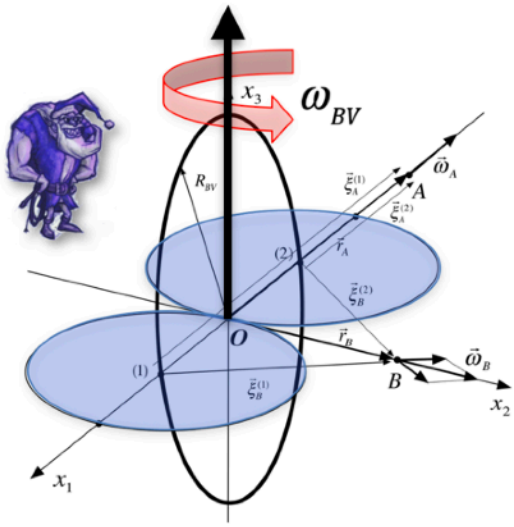
Admitting this conjecture, the "gravitational" perturbation field within the torus surrounding the twist disclination loop cannot be a solution of the static equation, and must therefore become *a dynamic internal "gravitational" perturbation field*, solution of Newton's second partial equation in figure 5.1. But around the loop, this Newton equation for dynamic perturbations is nothing other than the stationary Schrödinger equation in figure 11.4. It is therefore necessary to find a movement of the loop which is not a translation of it, but a movement confined to the same place in space. However, the only possible movement of the loop which is confined to the same place in space is actually a rotation of the latter on itself.

Classic rotation of a twist disclination loop (BV)

Let us therefore consider a twist disclination loop of radius R_{BV} as shown in figure 12.2, and imagine that it can rotate around a direction axis $\vec{e}_{axis}$ contained in the plane of the loop *with a pulsation* ω_{BV}, which is not impossible since the loop actually corresponds to *a screw pseudo-dislocation*. If we first deal with this problem in a conventional way, we can use polar coordinates to define *the angular momentum* $\vec{L}_{BV}$ of the loop around its axis of rotation, assuming the mass of the loop distributed uniformly over the surface of the loop, as illustrated in figure 12.2. As we know in fact only approximately the real distribution of the mass in the vicinity of the loop, we will introduce a numerical correction factor δ_1 such as $\delta_1 \cong 1$ in the calculation of $\vec{L}_{BV}$, as represented in figure 12.2.

We can then introduce *the moment of inertia of the loop* I_{BV} around the axis of rotation using the known relation $\vec{L}_{BV} \cong I_{BV}\omega_{BV}\vec{e}_{axis}$. As a twist disclination loop also has a rotation charge $\boldsymbol{q}_{\lambda BV}$, analogous to the electric charge, it also has *a «magnetic moment»* $\vec{\mu}_{BV}$ in the direction of the rotation axis which is defined in figure 12.2, *assuming the charge distributed on the contour of the loop*. As we only know approximately the distribution of the charge in the vicinity of the loop, we will also introduce a numerical correction factor δ_2 such as $\delta_2 \cong 1$. And then we find a direct relationship between the «magnetic moment» $\vec{\mu}_{BV}$ and the kinetic moment $\vec{L}_{BV}$ of this loop, which is called *the gyromagnetic ratio* g_{BV} which is roughly equal to $2\delta_2 / \delta_1 \cong 2$.

We can also calculate *the kinetic energy* $E_{rotation\,BV}^{cin}$ associated with this rotation movement around the axis of rotation, as shown in figure 12.2. With the corrective factor δ_1 on the distribution of mass within the loop, we obtain a value of the energy which is directly related to the angular momentum and the moment of inertia since $E_{rotation\,BV}^{cin} \cong \vec{L}_{BV}^2 / (2I_{BV})$.



Angular momentum $(\delta_1 \cong 1)$

$$\vec{L}_{BV} = \delta_1 \oint \vec{r} \wedge \vec{v}\, dm = \delta_1 \vec{e}_{axe} \int_0^{R_{BV}} 4 \int_0^{\pi/2} \underbrace{r\cos\theta}_{|\vec{r}|} \underbrace{r\cos\theta\, \omega_{BV}}_{|\vec{v}|} \underbrace{\frac{\delta_1 M_0^{BV}}{\pi R_{BV}^2} r d\theta dr}_{dm} = \delta_1 \frac{M_0^{BV} R_{BV}^2}{4} \omega_{BV} \vec{e}_{axis} \cong I_{BV} \omega_{BV} \vec{e}_{axis}$$

$$\rightarrow \quad I_{BV} = \delta_1 \frac{M_0^{BV} R_{BV}^2}{4} \quad \textit{(moment of inertia)}$$

Magnetic moment $(\delta_2 \cong 1)$

$$\vec{\mu}_{BV} = \delta_2 \frac{1}{2} \oint \vec{r} \wedge \vec{v}\, d\boldsymbol{q} = \delta_2 \vec{e}_{axis} 2 \int_0^{\pi/2} \underbrace{R_{BV}\cos\theta}_{|\vec{r}|} \underbrace{R_{BV}\cos\theta\, \omega_{BV}}_{|\vec{v}|} \underbrace{\frac{\boldsymbol{q}_{\lambda BV}}{2\pi} d\theta}_{dq} = \delta_2 \frac{R_{BV}^2 \boldsymbol{q}_{\lambda BV}}{4} \omega_{BV} \vec{e}_{axis} \cong g_{BV} \frac{\boldsymbol{q}_{\lambda BV}}{2M_0^{BV}} \vec{L}_{BV}$$

$$\rightarrow \quad g_{BV} = 2\frac{\delta_2}{\delta_1} \cong 2 \quad \textit{(gyromagnetic ratio)}$$

Kinetic energy

$$E_{rotationBV}^{cin} = \delta_1 \frac{1}{2} \oint \vec{v}^2\, dm = \delta_1 \int_0^{R_{BV}} 2 \int_0^{\pi/2} \underbrace{r^2 \cos^2\theta\, \omega^2}_{\vec{v}^2} \underbrace{\frac{M_0^{BV}}{\pi R_{BV}^2} r d\theta dr}_{dm} = \delta_1 \frac{M_0^{BV} R_{BV}^2}{8} \omega_{BV}^2 \cong \frac{2\vec{L}_{BV}^2}{\delta_1 M_0^{BV} R_{BV}^2} \cong \frac{\vec{L}_{BV}^2}{2I_{BV}}$$

Figure 12.2 *- Classic solution of rotation of the twist disclination loop: angular momentum, magnetic moment and kinetic energy*

Quantification of the angular momentum of the screw loop

Assuming that the twist disclination loop (BV) actually turns on itself, this microscopic movement of rotation will induce a field of gravitational fluctuations in the vicinity of the loop, depending on the second partial Newton equation of figure 5.1. Now we saw in the previous chapter that in the absence of a time-varying potential, Newton's second partial equation leads to the stationary Schrödinger equation in figure 11.4. The treatment of the rotation movement of a microscopic object around an axis by the stationary Schrödinger equation is succinctly summarized in figure 12.3.

For a particle subject to rotation, it is preferable to describe the operator $\hat{H}$ linked to the classical Hamiltonian in spherical coordinates (θ,φ). In the absence of a potential, this operator $\hat{H}$ is linked to the square operator of the angular momentum $\hat{L}^2$ by the last relation

obtained in figure 12.2. With the expression of this operator in spherical coordinates, we deduce the stationary Schrödinger's equation in spherical coordinates, whose stationary solutions have quantified energy levels $\varepsilon_j = \hbar^2 j(j+1)/(2I_{BV})$ of rotation. For each value of the energy ε_j corresponding to a given angular speed, there are $2j+1$ different eigenstates corresponding conventionally to different orientations of the axis of rotation. It is said that the energy state ε_j has a degeneracy of $2j+1$.

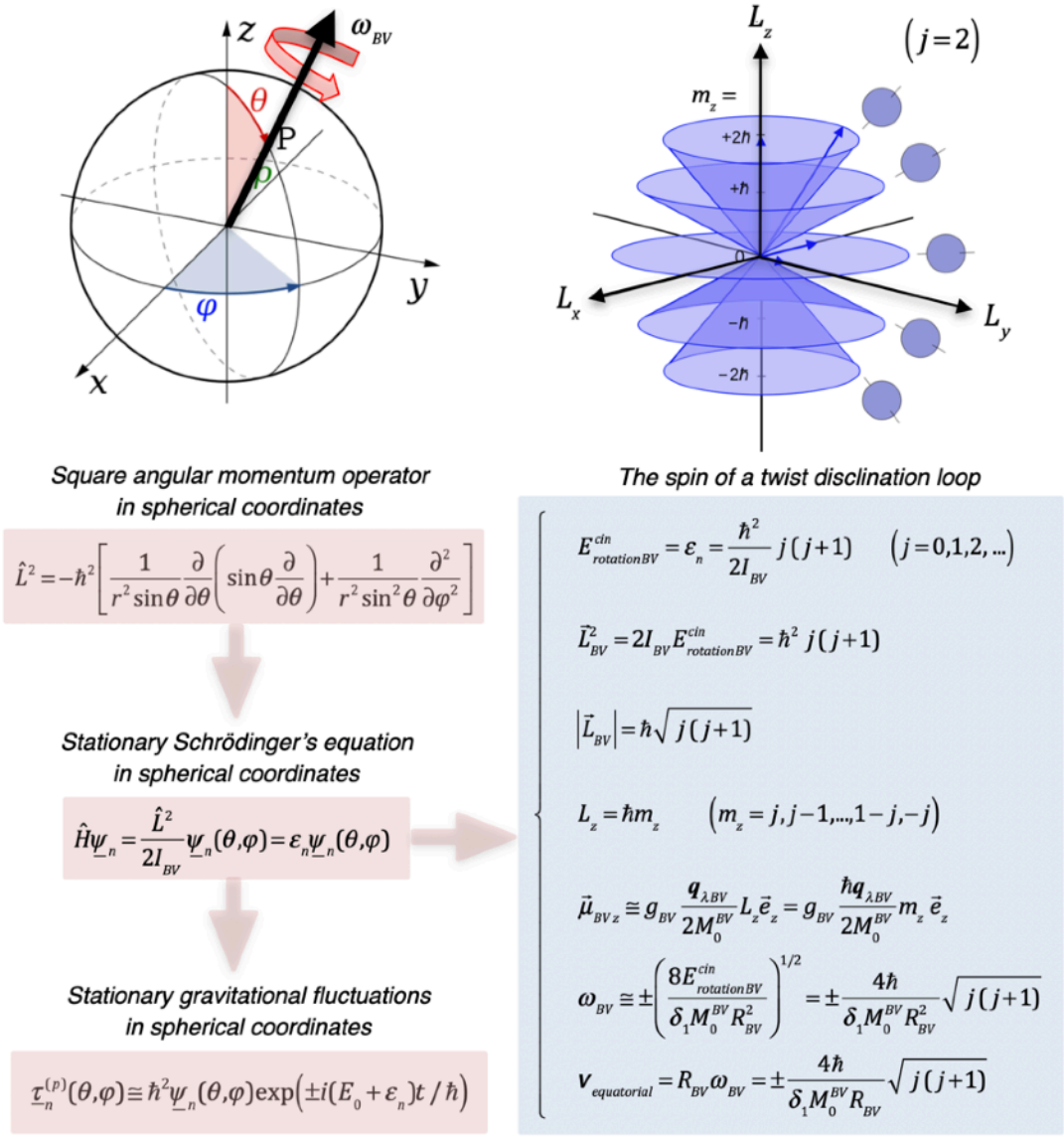


Figure 12.3 *- Quantum solution of rotation of the twist disclination loop: quantified rotational energy levels and magnetic quantum number* m_z

It is *the magnetic quantum number* m_z that characterizes the quantification of the projection of the angular momentum along a certain axis z. It can take the $2j+1$ following values $m_z = j, j-1, ..., 1-j, -j$, so that the projection L_z of the angular momentum on an axis Oz takes the values $L_z = \hbar m_z$. Apart from the kinetic energy and the kinetic momentum of the loop,

we still deduce *the quantized magnetic moment* of the loop along the axis Oz, which depends directly on the magnetic quantum number m_z, which also depends on *the Landé factor* g_{BV} of the screw loop, which is roughly equal to 2 in the case of the twist disclination loop, but which would depend on the distribution of mass and charge in the case of other types of topological singularities. We note that, in the expression of the quantified momentum, we then find the value of the famous *Bohr magneton*, namely $\hbar \boldsymbol{q}_{\lambda BV} / 2M_0^{BV}$.

Finally, the resolution of the stationary Schrödinger equation in this case makes it possible to deduce the eigen wave functions $\underline{\psi}_n(\theta,\varphi)$ correlated to the different energy levels ε_n, and to use them to obtain the stationary gravitational perturbations $\underline{\tau}_n^{(p)}(\theta,\varphi)$ in the immediate vicinity of the loop under the form $\underline{\tau}_n^{(p)}(\theta,\varphi) \cong \hbar^2 \underline{\psi}_n(\theta,\varphi) \exp\left(\pm i(E_0+\varepsilon_n)t/\hbar\right)$.

About the completely classic interpretation of the spin of a particle

In quantum physics, the spin of a charged particle like the electron was initially attributed to a proper rotation of the particle. However, the fact that the electron is considered a spherical particle, which is extremely small, has raised doubts about this "classic" interpretation of spin. But the strongest argument for abandoning this "classic" interpretation, although the effects of spin like the magnetic moment of the electron correspond strictly to a proper rotation of the particle on itself, is the fact that calculating the equatorial speed of rotation of the electron gives a speed much higher than the speed of light, which does not at all fit with the theory of Special Relativity.

But it is quite different in our approach. Indeed, let us try to calculate the equatorial speed in the case of the twist disclination loop, which is obtained from its radius R_{BV} and the pulsation ω_{BV} of its rotation movement as $\boldsymbol{v}_{equatorial} = R_{BV}\omega_{BV}$. To determine the rotation pulsation ω_{BV}, we equal the classical kinetic energy of rotation of the loop to its kinetic energy determined via the Schrödinger equation, and we obtain the expressions for ω_{BV} and $\boldsymbol{v}_{equatorial}$ reported in figure 12.3. Numerically, let's use the known values of the electron, namely its mass $M_0^{BV} \equiv M_0^{electron} = 9{,}1 \bullet 10^{-31}\left[kg\right](\vec{\xi},t)$, its approximate radius on the order of $10^{-18}\left[m\right]$, the value of δ_1 equal approximatively to 1, the value of the Planck constant $\hbar \equiv 6{,}6 \bullet 10^{-34}\left[m^2 kg/s\right]$, and its known spin of $j = 1/2$, and it then comes the following approximative value of the equatorial speed $\boldsymbol{v}_{équatoriale} \cong 2{,}5 \bullet 10^{15}\left[m/s\right]$. We find that the equatorial speed of rotation of the loop is much greater than the speed of light $c_{t0} \equiv c = 3{,}3 \bullet 10^8\left[m/s\right]$ within the lattice, as the pioneers of quantum physics had found.

But a completely new fact comes into our approach, which is the enormous static volume expansion in the immediate vicinity of the rotating loop. Indeed, let's express the static volume expansion at the limit of the torus where expansion perturbations can become static. At this limit, the static volume expansion is maximum, and it is given by the unique solution of the equation for $\tau_{int}^{BV}(\vec{\xi})$ in figure 12.1 when the term under the root is zero, and we obtain that $\tau_{static\,max}^{BV} = \left[K_0 - 4K_2/3 - 2K_1(1+\tau_0)\right]/(2K_1) \cong K_0/(2K_1)$. We therefore deduce that the actual speed of the transverse waves in the immediate vicinity of the loop is in fact worth $c_t\big|_{limite} \cong c_{t0}\, e^{\tau_{static\,max}^{BV}/2} \cong c_{t0} \exp(K_0/4K_1)$. Therefore, the speed $c_t\big|_{limit}$ is certainly much higher than $c_{t0} \equiv c = 3{,}3 \bullet 10^8\left[m/s\right]$ since $K_0/K_1 >> 1$. In fact, it is enough that $c_t\big|_{limit} \cong c_{t0} \exp(K_0/4K_1) > \boldsymbol{v}_{equatorial} \cong 2{,}5 \bullet 10^{15}\left[m/s\right]$ for the equatorial speed of rotation of the loop to be possible. We can try to determine what is the limit value of the module K_1 so that

the rotation of the loop is possible. It's very easy to get that we need just to have that $K_1 / K_0 < 1,6 \bullet 10^{-2}$. Now this condition is always satisfied since we need, from conjecture 6, that $K_1 / K_0 << 1$. We are therefore assured that, *in our approach*, the rotation movement of the loop on itself is not only perfectly possible, but that it is *especially compulsory* since it is the only possible solution to Newton's second partial equation.

We therefore conclude that there is once again a completely "classic" explanation of the notion of spin of a particle, as a real quantified movement of rotation of the loop around an axis, which does not infringe in any way the principles of special relativity. This explanation removes on the one hand all the mysterious side of the notion of spin in quantum physics, and on the other hand perfectly explains the existence of a quantified magnetic momentum of spin of the electron, directly associated with the real rotation of the charged loop.

About the problem of the spin value of a topological loop

If the existence of a proper rotation of the loops is a necessity in our approach to satisfy Newton's second partial equation in the immediate vicinity of the loop, there is still a question to which we have no answer: what value must it attribute to the spin of the loop? Otherwise formulated, this question amounts to looking for the value to be assigned to the azimuthal quantum number j which characterizes the quantification of the energy of rotation and the angular momentum of the loop, as well as its magnetic moment (figure 12.3).

Experimentally, we know that the spin of the electron is worth $j = 1/2$ and that the spin of the intermediate boson W^- is worth $j = 1$. But the underlying reason why these particles have these particular values remains very mysterious. In our approach, the same goes: apart from the fact that the spin $j = 1/2$ and $j = 1$ are the weakest, and therefore correspond to the lowest possible kinetic energies, no reasonable argument allows for the moment to make a choice of the value of j to choose for a twist disclination loop. So let's look at the effect of a spin $j = 1/2$ or a spin $j = 1$ on a twist disclination loop:

- Loop of twist disclination with a spin 1/2

Consider a twist disclination loop of spin 1/2. Whatever the direction of the axis of rotation, there can only be two eigenstates of the loop, corresponding to a dextrorotatory or levorotatory rotation of the loop around the axis of rotation, since the state of degeneracy of the energy is in this case of $2j+1=2$. The kinetic energy and the kinetic momentum of the loop become therefore $E^{cin}_{rotationBV} = 3\hbar^2 / (8I_{BV})$ and $\left|\vec{L}_{BV}\right| = \hbar\sqrt{3}/2$ in this case. As for the magnetic quantum number m_z, it can take the two values $m_z = \pm 1/2$ so that the projection L_z of the angular momentum on an axis Oz takes the values $\pm\hbar/2$. So here we find exactly the notion of spin of *a particle of spin 1/2*. The magnetic moment of the loop along the axis Oz is then written $\vec{\mu}_{BVz} \cong \pm g_{BV}\hbar \boldsymbol{q}_{\lambda BV}\vec{e}_z / (4M_0^{BV})$ with $g_{BV} \cong 2$.

- Loop of twist disclination with a spin 1

Now consider a twist disclination loop of spin 1. Whatever the direction of the axis of rotation, there can then be only three eigenstates of the loop, corresponding to a dextrorotatory rotation, to a levorotatory rotation, or to no rotation of the loop around its axis of rotation, since the state of degeneracy of the energy is worth $2j+1=3$. in this case. The kinetic energy and the kinetic momentum of the loop are worth $E^{cin}_{rotationBV} = \hbar^2 / I_{BV}$ and $\left|\vec{L}_{BV}\right| = \hbar\sqrt{2}$ respectively. As for the

magnetic quantum number m_z, it can take the following three valuess $m_z = -1, 0, +1$ so that the projection L_z of the angular momentum on an axis takes the values 0 and $\pm\hbar/2$. We thus find here exactly the notion of spin of *a particle of spin 1*. The magnetic moment of the loop along the axis Oz is then written $\vec{\mu}_{BVz} \cong 0, \pm g_{BV}\hbar \boldsymbol{q}_{\lambda BV}\vec{e}_z/(2M_0^{BV})$ with $g_{BV} \cong 2$.

About the link between the concepts of bosons, fermions and spin

The question of knowing if a loop of topological singularity behaves like a fermion or a boson in the event of superposition of several loops (see chapter 11) and the question of the value of the spin of a loop of topological singularity are undoubtedly very closely linked. Indeed, we know from quantum physics that fermions have a spin of 1/2 and that bosons have a spin of 1. From quantum physics, we also know that the spin component of the wave function Ψ of two particles is symmetric when the spins of the two particles are parallel, and antisymmetric if the spins are anti-parallel, and we therefore have the following possibilities for the wave function Ψ of two particles:

• *Fermions:* antisymmetric wave function $\Rightarrow$ parallel spins and antisymmetric spatial component, or anti-parallel spins and symmetric spatial component.

• *Bosons:* symmetric wave function $\Rightarrow$ parallel spins and symmetric spatial component, or anti-parallel spins and antisymmetric spatial component.

It would be very interesting to explore this problem further, and to see what topological interpretation to give it within the framework of our approach of topological loops. We will return to this problem in Chapter 13 dealing with the standard particle model.

About the very important consequences of the existence of spin on the cosmological behavior of the lattice

The fact that there is a spin of particles has very important consequences for the cosmological behavior of the lattice. Indeed, as the presence of the spin implies *(i)* that $K_1 > K_{1cr}$, with $K_{1cr} \cong 10^{-21}$ for the electron, and *(ii)* that $K_1/K_0 < 1{,}6 \bullet 10^{-2}$, we deduce that $K_1 > 0$, so that *the expansion of the lattice cannot be infinite* and that we find ourselves necessarily in one of the universe oscillating between big-bang and big-crunch. By adding to this condition on K_1 the conditions drawn from conjecture 6, in particular that $K_0 = K_3 >> K_1 > 0$, we deduce that *there is only one admissible behavior for the cosmological evolution of the lattice* corresponding to figures 3.8 (g) and 3.10.