Cosmic optical activity in the spacetime of a scalar-tensor screwed cosmic string

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Abstract

Measurements of the quasars optical activities verify that their polarization vectors are not randomly oriented as naturally expected. In order to give a possible explanation to this phenomenon we investigate the role played by a Chern-Simons-type term in the scalar-tensor screwed cosmic string (SCS) background. In this scenario we discuss the possibility that the quasar optical polarization can be explained by considering that the electromagnetic waves emitted by these quasars interact with a scalar-tensor screwed cosmic string through a Chern-Simons-type coupling. We use this screwed cosmic string to put limit in the coupling constant. The superconducting case has also been discussed and the results compared with general relativity effects.

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1 Introduction

The Cosmological Principle postulates that the Universe is homogenous and isotopic. Thus, in order to preserve this Principle, a polarized electromagnetic radiation that propagates across the Universe has its plane of polarization rotated by the Faraday effect, which removes, in principle, this polarization. However, some of the measurements detect that the linearly polarized light emitted by distant quasars presents an additional rotation, which remains even after Faraday rotation is extracted. This may represent evidence for cosmological anisotropy on large scale\cite{1, 2}.

Hutsemékers and Lamy \cite{2} found that the quasar polarization vectors are not randomly oriented on the sky as standard understanding suggested. To confirm this effect they have studied a sample of 170 optically polarized quasars with accurate polarization measurements. Their analysis showed that in some regions the quasar polarization position angles appear concentrated around preferential directions, what suggests the existence of large-scale coherent orientations or alignments of quasar polarization vectors. In their measurements, the hypothesis of uniform distribution of polarization position angles may be rejected at the 1.8 \% significance level\cite{2}. Though the sample seems to be statistically significant, further surveys confirm its unexpected nature. The occurrence of coherent orientations over cosmic distances, they claimed, seems to point towards the existence of new non-standard effects relevant to cosmology.

Other authors have claimed to find evidence for cosmological birefringence \cite{3, 4}, but these data were considered no statistically significant signal by many authors \cite{5, 6}. However, these actual evidences\cite{2} give new motivations to investigate more detailed this possibility.

The possible existence of a preferred direction over cosmological distances has been discussed in the context of theories of gravitation\cite{7} and observational cosmology\cite{8}. Such a phenomenon, if it exists, would imply the violation of the Lorentz invariance\cite{7}, bringing unpredictable consequences for fundamental physics\cite{9}.

The idea that intergalactic space is a birefringent medium has been considered for a long time. In this case the intergalactic medium contains neutral atoms and microwave radiation immersed in a neutrino or antineutrino sea\cite{10}. The sea is very hard to detect experimentally\cite{11, 12} as a result of its low energy and its exclusively weak interactions. Electromagnetic radiation travelling though the intergalactic medium interact with its components, and if this radiation is initially plane polarized, the plane of polarization would rotate. Two possible sources of optical activity have already been studied. They are the scattering produced by atoms and by the neutrino sea.

Here, instead of the idea of a neutrino sea interacting with the electromagnetic radiation, we will consider that screwed scalar-tensor background has the same effect, i.e., the plane polarized electromagnetic radiation has the plane of polarization rotated when it is travelling though the spacetime generated by this screwed cosmic string. In the literature, the association of such anisotropy with a torsion background has been considered\cite{13, 14, 15, 16}. On the other hand, the assumption that gravity may be in-
intermediated by a scalar field (or, more generally, by many scalar fields) in addition to the usual symmetric rank-2 tensor has considerably revived in recent years. It has been argued that gravity may be described by a scalar-tensor gravitational field, at least at sufficiently high energy scales. From the theoretical point of view, scalar-tensor theories of gravitation, in which the gravitational interaction is mediated by one or several long-range scalar fields in addition to the usual tensor field present in Einstein’s theory, are the most natural alternatives to general relativity. In these theories the gravitational interaction is mediated by a (spin-2) graviton and by a (spin-0) scalar field [17, 18]. If gravity is essentially a scalar-tensor theory, there will be direct implications for cosmology and experimental tests of the gravitational interaction[19]. In particular, any gravitational phenomena will be affected by the variation of the gravitational constant $\tilde{G}_0$. At sufficiently high energy scales where gravity becomes scalar-tensor in nature [20], it seems worthwhile to analyse the behaviour of matter in the presence of a scalar-tensor gravitational field, specially those which originated in the early universe, such as cosmic strings. In this context, some authors have studied solutions for cosmic strings and domain walls in Brans-Dicke [21], in dilaton theory [22] and in situations with more general scalar-tensor couplings [23].

The dilaton-torsion identification was previously made in a modified scalar-tensor theory, where the torsion field is generated by a scalar field[24]. The torsion is important from the phenomenological point of view and it may be relevant in cosmology. This importance is associated with the modifications of the kinematic quantities, like shear, vorticity, acceleration, expansion and their evolution equations due to the presence of torsion[25, 26, 27, 28, 29].

Cosmic string [30] is a topological defect which may has been formed during phase transitions in the realm of the early Universe[31]. Its gravitational field, in the context of General Relativity is quite remarkable: a particle placed at rest around a straight, infinite, static cosmic string will not be attracted to it. The richness of the new ideas this defect brought along general relativity seems to justify the interest in the study of this structure and specifically the role played by it in the framework of Cosmology due to the fact that it carries a large energy density and for this reason it could be a potential sources for primordial density perturbations.

In this paper, we will consider the Chern-Simons-type term in the space-time of a screwed cosmic string in scalar-tensor gravities in order to explain the measurement concerning the optical activity of radio waves emitted by distant quasar which indicate an anisotropy over cosmological distances.

This paper is organized as follows: In Section II we introduce the physics of the scalar-tensor screwed cosmic string(SCS). In Section III, the dilatonic solution for the SCS is used as a background to study the gauge invariant Chern-Simons term. In Section IV, we study the superconducting case and compare with general relativity effects. Finally, in Section V we discuss the obtained results and the possibility of use this approach in order to explain the data about the optical activity of quasars.
2 Screwed cosmic string in scalar tensor theory

The scalar-tensor theory of gravity with torsion is an extension of Einstein’s General Relativity to which a scalar field is coupled minimally to the gravitational field and a dynamical torsion term is considered additionally.

This coupling is referred to the Jordan-Fierz frame, where the action takes the form

\[
I = \frac{1}{16\pi} \int d^4x \sqrt{-\tilde{g}} \left[ \tilde{\phi}^4 \tilde{R} - \frac{\omega}{\phi} \partial_\mu \tilde{\phi} \partial^\mu \tilde{\phi} \right] + I_m(\tilde{g}_{\mu\nu}, \Psi).
\]  

(2.1)

where \( I_m(\tilde{g}_{\mu\nu}, \Psi) \) is the action of the matter, which in the general case takes into account all fields. Here we will consider the presence of action spinor fields in the action. The function \( \omega \) in a general scalar-tensor theory has a \( \tilde{\phi} \) dependence, but in the specific case of Brans-Dicke theory it is a constant.

In this case the scalar curvature \( \tilde{R} \) given by (2.1) in the Jordan-Fierz frame can be written as

\[
\tilde{R} = \tilde{R}(\{\}) + \epsilon \frac{\partial_\mu \tilde{\phi} \partial^\mu \tilde{\phi}}{\tilde{\phi}^2},
\]

(2.2)

where \( \tilde{R}(\{\}) \) is the Riemann scalar curvature in the Jordan-Fierz frame and \( \epsilon \) is the torsion coupling constant[18].

It is worth commenting that in the scalar curvature \( \tilde{R} \), the scalar function \( \tilde{\phi} \) can act as a source of the torsion field. Therefore, in absence of spins, the torsion field may be generated by the gradient of the scalar field [24]. Thus, in this case the torsion can be propagated with the scalar field which can be written as

\[
S^\lambda_{\mu\nu} = (\delta^\lambda_\mu \partial_\nu \tilde{\phi} - \delta^\lambda_\nu \partial_\mu \tilde{\phi})/2\tilde{\phi}.
\]

(2.3)

The most general affine connection \( \Gamma^\alpha_{\lambda\nu} \) is given in terms of the contortion tensor \( K^\lambda_{\lambda\nu} \) by

\[
\Gamma^\alpha_{\lambda\nu} = \{^\alpha_{\lambda\nu}\} + K^\lambda_{\lambda\nu},
\]

(2.4)

where the quantity \( \{^\alpha_{\lambda\nu}\} \) is the Christoffel symbol computed from the metric tensor \( g_{\mu\nu} \) and the contortion tensor \( K^\lambda_{\lambda\nu} \) can be written in terms of the torsion field as

\[
K^\lambda_{\lambda\nu} = -\frac{1}{2}(S^\alpha_{\nu\lambda} + S^\alpha_{\lambda\nu} - S^\alpha_{\lambda\nu}).
\]

(2.5)

Although action (2.1) shows explicitly this scalar-tensor gravity’s character, for technical reasons, we will adopt the Einstein frame( conformal frame) in which the kinematic terms of the scalar and the tensor fields do not mix. In this frame, the action is given by

\[
I = \frac{1}{16\pi G} \int d^4x \sqrt{-g} \left[ R - 2g^{\mu\nu} \partial_\mu \phi \partial_\nu \phi \right] + I_m[\Psi_m, \Omega^2(\phi)g_{\mu\nu}],
\]

(2.6)
where $g_{\mu\nu}$ is a pure rank-2 tensor in the Einstein frame and $R$ is the curvature scalar given by

$$R = R(\{} + 4\epsilon\alpha(\phi)^2\partial_\mu\phi\partial^\mu\phi. \quad (2.7)$$

It is interesting to call attention to the fact that action (2.6) is obtained from (2.1) by a conformal transformation

$$\tilde{g}_{\mu\nu} = \Omega^2(\phi)g_{\mu\nu}, \quad (2.8)$$

and by a redefinition of the quantity

$$G\Omega^2(\phi) = \tilde{\phi}^{-1},$$

which makes evident that any gravitational phenomena will be affected by the variation of the gravitational constant $G$ in the scalar-tensor gravity and by a new parameter defined by

$$\alpha^2 \equiv \left(\frac{\partial \ln \Omega(\phi)}{\partial \phi}\right)^2 = [2\omega(\tilde{\phi}) + 3]^{-1},$$

which can be interpreted as the field-dependent coupling strength between matter and the scalar field.

In order to make our calculations as general as possible, we will not fix the factors $\Omega(\phi)$ and $\alpha(\phi)$ (the field-dependent coupling strength between matter and the scalar field), leaving them as arbitrary functions of the scalar field.

In the conformal frame, the Einstein equations are modified. A straightforward calculation shows that they turn into

$$R_{\mu\nu} = 2\xi\partial_\mu\phi\partial_\nu\phi + 8\pi G(T_{\mu\nu} - g_{\mu\nu}T), \quad (2.9)$$

$$G_{\mu\nu} = 2\xi\partial_\mu\phi\partial_\nu\phi - \xi g_{\mu\nu}g^{\alpha\beta}\partial_\alpha\phi\partial_\beta\phi + 8\pi GT_{\mu\nu}, \quad (2.10)$$

where $\xi$ is defined by

$$\xi(\phi) = 1 - 2\epsilon\alpha(\phi)^2 \quad (2.11)$$

which contains two contributions: one comes from the scalar-tensor term and the other from the torsion.

In the scalar-tensor theory, the Einstein equations are modified by the presence of the field $\phi$ and are obtained by applying the variational principle to (2.6). Thus, the equation for $\phi$ reads as

$$\Box g_\phi = -4\pi G\alpha(\phi)T, \quad (2.12)$$
where
\[
\Box_g \phi = \frac{\xi}{\sqrt{-g}} \partial_\mu \left( \sqrt{-g} \partial^\mu \phi \right).
\] (2.13)

It brings some new information because it does not appear in general relativity and shows us that a matter distribution in the space behaves like a source for \( \phi \), and, as usual, for \( g_{\mu \nu} \) as well. Up to now, we have dealt with the purely gravitational sector, but in what follows, we will introduce the action for the matter that describes a cosmic string.

In order to describe the simplest cosmic string in a scalar-tensor theory, we require the matter action to carry a complex scalar and gauge fields, in an Abelian Higgs model with symmetry \( U(1) \) whose action is given by
\[
I_m = \int d^4x \sqrt{\tilde{g}} \left[ -\frac{1}{2} D_\mu \Phi (D^\mu \Phi)^* - \frac{1}{4} F_{\mu \nu} F^{\mu \nu} - V(|\Phi|) \right],
\] (2.14)
where \( D_\mu \Phi = (\partial_\mu + iq A_\mu) \Phi \) is the covariant derivatives. The reason why the gauge fields do not minimally couple to torsion is well discussed in Refs.[18, 32]. The field strengths are defined as usually as \( F_{\mu \nu} = \partial_\mu A_\nu - \partial_\nu A_\mu \) with \( A_\mu \) being the gauge field and \( V(|\Phi|) \) the potential.

This action given by Eq.(2.1) has a \( U(1) \) symmetry, where the \( U(1) \) group, associated with the \( \Phi \)-field, is broken by the vacuum and gives rise to vortices of the Nielsen-Olesen type[33]
\[
\Phi = \varphi(r) e^{i \theta},
A_\mu = \frac{1}{\delta}[P(r) - 1] \delta^\mu_\theta,
\] (2.15)
in which \((t, r, \theta, z)\) are usual cylindrical coordinates. The boundary conditions for the fields \( \varphi(r) \) and \( P(r) \) are the same as those of ordinary cosmic strings[33], namely
\[
\varphi(r) = \eta, \quad r \to \infty, \quad P(r) = 0, \quad r \to \infty, \\
\varphi(r) = 0, \quad r = 0, \quad P(r) = 1, \quad r = 0.
\] (2.16)

The potential \( V(\varphi) \) triggering the spontaneous symmetry breaking can be fixed by
\[
V(\varphi) = \frac{\lambda_\varphi}{4} (\varphi^2 - \eta^2)^2,
\] (2.17)
where \( \lambda_\varphi \) is a coupling constant. Constructed in this way, this potential possesses all the ingredients that make it viable to generate the formation of a cosmic string, as it is well established.

If we solve the Einstein-Cartan equations and transform to the Jordan-Fiertz frame using a conformal transformation, Eq.(2.8), we find the metric of a static, straight axially symmetric screwed cosmic string in scalar-tensor gravity which is given by[34]
\[
ds^2 = [1 + 8G_0 \mu \xi^{-1} \alpha^2 (\phi_0) \ln p/r_0][-dt^2 + dz^2 + d\rho^2 + (1 - 8G_0 \mu \rho^2) d\theta^2],
\] (2.18)
where $G_0$ is defined as $G_0 \equiv G \Omega^2(\phi_0)$ and we have used the fact that for a cosmic string the linearized solution of the equation $\text{Eq.}(2.12)$ is given by

$$\phi_{(1)} = 4G_0 \alpha(\phi_0) \xi^{-1} \mu \ln \frac{\rho}{r_0}.$$  \hspace{1cm} (2.19)

The constant $r_0$ appearing in the Eqs.(2.18) and (2.19) is an integration constant and is chosen, for convenience, as having the same order of magnitude of the string’s radius.

The metric given by $\text{Eq.}(2.18)$ can be obtained from the one corresponding to the superconducting cosmic string[34], by considering the limit when the current vanishes.

### 3 Chern-Simons like term in a screwed scalar-tensor cosmic string background

Recent quasar optical polarization measurements predict that in a region of sky, the quasar polarization vectors are not randomly oriented as naturally expected, but appear concentrated around a preferential direction[2]. In order to get a possible explanation to this phenomenon, we will consider the modification of the Maxwell action density by adding to this a Chern-Simons like term

$$S_{\text{eff}} = \int d^4x \sqrt{g} \left( -\frac{1}{4} F_{\mu\nu} F^{\mu\nu} - \frac{1}{3!} \lambda \varepsilon^{\mu\nu\alpha\beta} F_{\mu\nu} A_\alpha S_\beta \right),$$ \hspace{1cm} (3.1)

in which we couple the electromagnetic field $F_{\mu\nu}$ and the vector potential $A_\alpha$ to the torsion vector $S_\beta$, responsible for the appearance of the preferred cosmic direction, as suggested by the observations[3]. Then, we will investigate the role played by the Chern-Simons like term in the scalar-tensor screwed cosmic string background.

In this paper we will consider the case where $S_\mu$ is a gradient of a scalar for some scalar $\phi$ that preserve the gauge invariance but not the Lorentz invariance.

In scalar-tensor screwed cosmic string background, we can consider this scalar $\phi$ as the dilaton. Thus, using (2.3), the torsion vector in the Jordan-Fierz frame is given by

$$S_\mu = \frac{3}{2} \partial_\mu \ln \tilde{\phi}.$$ \hspace{1cm} (3.2)

Putting the linearized solution given by $\text{Eq.}(2.19)$ into $\text{Eq.}(3.2)$, we have

$$S_\mu = -3\alpha(\phi_0) \partial_\mu \phi_{(1)}.$$ \hspace{1cm} (3.3)

In this context, the field equation of the electromagnetic field is

$$\frac{1}{\sqrt{-g}} \partial_\mu \left[ \sqrt{-g} F^{\mu\nu} \right] = \lambda \alpha(\phi_0) \tilde{F}^{\mu\nu} \partial_\mu \phi_{(1)}.$$ \hspace{1cm} (3.4)

The solutions of the $\text{Eq.}(3.4)$ give us the corresponding dispersion relation
\[(k^\alpha k_\alpha)^2 + (k^\alpha k_\alpha)(S^\beta S_\beta) = (k^\alpha S_\alpha)^2 \] (3.5)

with \(\omega\) and \(k\) being the wave frequency and the wave vector, respectively, and form the four-vector \(k^\alpha = (\omega, \mathbf{k})\); \(k = |\mathbf{k}|\).

Since we expect \(S_\alpha\) to be small, thus we can expand the dispersion relation (3.5) in powers of \(S_\alpha\). Then, using Eq.(3.3) and substituting \(\phi(1)\) given by (2.19), we get to first order, the following result

\[k_\pm = \omega \pm 2\lambda \xi^{-1} G_0 \mu_\alpha (\phi_0)^2 s \cos(\gamma),\] (3.6)

where \(\gamma\) is the angle between the propagation wave vector \(\mathbf{k}\) of the radiation and the unit vector \(\hat{s}\) and the propagation direction \(\mathbf{\kappa}\).

4 Screwed superconducting cosmic string effects

We have already studied the screwed superconducting cosmic string in a recent work [34]. In order to describe the simplest superconducting cosmic string in a scalar-tensor theory, we require the matter action to carry a pair of complex scalar and gauge fields, in an Abelian Higgs model whose action is given by

\[I_m = \int d^4x \sqrt{g} \left[ -\frac{1}{2} D_\mu \Phi (D^\mu \Phi)^* - \frac{1}{2} D_\mu \Sigma (D^\mu \Sigma)^* - \frac{1}{4} F_{\mu\nu} F^{\mu\nu} - \frac{1}{4} H_{\mu\nu} H^{\mu\nu} - V(|\Phi|, |\Sigma|) \right],\] (4.1)

where \(D_\mu \Sigma = (\partial_\mu + i A_\mu) \Sigma\) and \(D_\mu \Phi = (\partial_\mu + i C_\mu) \Phi\) are the covariant derivatives. The field strengths are defined as usual as \(F_{\mu\nu} = \partial_\mu A_\nu - \partial_\nu A_\mu\) and \(H_{\mu\nu} = \partial_\mu C_\nu - \partial_\nu C_\mu\), with \(A_\mu\) and \(C_\mu\) being the gauge fields.

This action given by Eq.(4.1) has a \(U(1) \times U(1)\)' symmetry, where the \(U(1)\) group, associated with the \(\phi\)-field, is broken by the vacuum and gives rise to vortices of the Nielsen-Olesen type[33].

The other \(U(1)'\) symmetry, that we associate with electromagnetism, acts on the \(\Sigma\)-field. This symmetry is not broken by the vacuum; however, it is broken in the interior of the defect. The \(\Sigma\)-field in the string core, where it acquires an expectation value, is responsible for a bosonic current being carried by the gauge field \(A_\mu\). The only non-vanishing components of the gauge fields are \(A_z(r)\) and \(A_t(r)\), and the current-carrier phase may be expressed as \(\zeta(z, t) = \omega_1 t - \omega_2 z\). Notwithstanding, we focus only on the magnetic case. Their configurations are defined as

\[\Sigma = \sigma(r) e^{i \zeta(z,t)},\]
\[A_\mu = \frac{1}{\sigma} [A(r) - \frac{\partial \zeta(z,t)}{\partial z}] \delta_x^\mu,\] (4.2)

because of the rotational symmetry of the string itself. The fields responsible for the cosmic string superconductivity have the following boundary conditions
\[
\frac{d}{dr}\sigma(r) = 0, \quad r = 0, \quad A(r) \neq 0, \quad r \to \infty, \\
\sigma(r) = 0, \quad r \to \infty, \quad A(r) = 1, \quad r = 0.
\] (4.3)

The potential \(V(\varphi, \sigma)\) triggering the spontaneous symmetry breaking can be fixed by

\[
V(\varphi, \sigma) = \frac{\lambda}{4}(\varphi^2 - \eta^2)^2 + f_{\varphi\sigma}\varphi^2\sigma^2 + \frac{\lambda}{4}\sigma^4 - \frac{m^2}{2}\sigma^2, \quad (4.4)
\]

where \(\lambda_{\varphi}, \lambda_{\sigma}, f_{\varphi\sigma}\) and \(m_{\sigma}\) are coupling constants. Constructed in this way, this potential possesses all the ingredients that make it viable to generate the formation of a superconducting cosmic string, as it is well established.

We shall adopt the same procedure of the last section to obtain the dilaton solution in the superconducting case. For a superconducting cosmic string[34], the equation given by (3.4) is complicated, but if we assume that we are very far from the source, then, the gravitational coupling can be neglected, and we have

\[
\phi(1) = 4G_0\alpha(\phi_0)\xi^{-1}(\mu + \tau - I^2)\ln\frac{\rho}{r_0} \quad (4.5)
\]

Working out the dynamics of the interaction given by Eq.(3.1), we get a dispersion relation. Since we expect \(S_\alpha\) to be small, we can expand the dispersion relation (3.5) in powers of \(S_\alpha\) to obtain, to first order,

\[
k_{\pm} = \omega \pm 2\lambda\xi^{-1}G_0(\mu + \tau - I^2)\alpha(\phi_0)^2s\cos(\gamma), \quad (4.6)
\]

In this case, the parameter \(I\) is the current in the vortex and \(\tau\) is the tension of the string. We have already known that the polarization of the radiation moving through an intervening magnetized plasma must be removed using the fact that Faraday rotation is proportional to the square of the wavelength. In the case of the superconducting cosmic string in general relativity there is no residual polarization related with the anisotropy after removing the Faraday rotation. In this paper we show that in the scalar-tensor theories of gravity, this is not the situation. In fact, the polarization effect is present even after the Faraday rotation is removed. The scalar coupling has a current carrying contribution given by \(\tau\) and the current \(I\) that appear in equation (4.6). In this case we note that the current \(I\) has the negative contribution.

In next section we will analyze this theoretical results with the experimental measurements by Nodland and Ralston data to galaxies [3]. But this analyze type so validity is, if we used the quasars parameters, to study the polarization properties of broad absorption line quasars that have recently obtained with a new optical polarization measurements for a sample of moderate to high-redshift quasars[1].
5 Discussions and Remarks

Let us analyse our theoretical results in the framework of the observational data obtained by Nodland and Ralston data[3]. In their analysis of the data of about 73 high-redshift radio-emitting galaxies, they found correlations between the direction and the distance to a galaxy. The angle $\beta$ between the polarization vector and the galaxy’s major axis is

$$<\beta> = \frac{1}{2} \frac{r}{\Lambda_s} \cos(\vec{k}, \vec{s}),$$  \hspace{1cm} (5.1)

where $\beta$ represents the mean rotation angle after Faraday’s rotation is removed, $r$ is the distance to the galaxy, $\vec{k}$ the wavevector of the radiation, and $\vec{s}$ (a unit vector) $\equiv (315^0 \pm 30^0, 0^0 \pm 20^0)$, is the preferred direction in the sky, given here in equatorial celestial coordinates (r.a.,dec.).

The rotation of the polarization plane is a consequence of the difference in the propagation speed of the two modes. This difference is

$$\frac{1}{2}(\kappa_+ - \kappa_-) = \frac{\beta}{dr}$$  \hspace{1cm} (5.2)

where $\beta$ a measures the rotation of the polarization plane, per unit length $r$, and is given by

$$\beta = \frac{1}{2} \Lambda_s^{-1} r \cos \gamma$$  \hspace{1cm} (5.3)

In the case of the screwed cosmic string, the constant $\Lambda_s$ can be written as a function of the energy density $\mu$ as

$$\Lambda_s^{-1} = 4G_0 \lambda^{-1} \alpha(\phi_0)^2 \mu.$$  \hspace{1cm} (5.4)

It is illustrative to consider a particular form for the arbitrary function $\Lambda(\phi)$, corresponding to the Brans-Dicke theory, namely, $\Omega = e^{\alpha \phi}$, with $\alpha^2 = \frac{1}{2w+3}$. ($w=$cte). Using the values for $w$ such that $w > 2500$ (consistent with solar system experiments made by Very Baseline Interferometry (VLBI) [36]. In this case $G_0 = G_s \Omega^2(\phi_0) = (\frac{2w+3}{2w+4}) G_{eff}$ [37] where $G_{eff}$ is the Newtonian constant.

In this way, for an ordinary screwed cosmic string, we have

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<tr>
<th>$G_0 \mu \sim 10^{-6}$</th>
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<tr>
<td>$\alpha^2 \sim 2 \times 10^{-2}$</td>
<td>Brans Dicke gravity</td>
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<td>$\xi = 1$</td>
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<tr>
<td>$\Lambda_s^{-1} = 10^{-32} eV$</td>
<td>by Nodland and Ralston</td>
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With these data, we can put limit in the coupling constant $\lambda \sim 10^{-26} eV$. This result is very interesting because it permits to fit the observational data. In this way we show that the general scalar-tensor theory can give us an interesting explanation to these observational data about optical activity measurements.
Although the idea has been contentious[38, 39, 40], its likely realisation is not fully excluded[41]. Thus, there seems to be room for potential explanations of the origin of such a preferred direction on the sky. In fact, a possible connection of this effect with the existence of a cosmic rotation axis was pointed out in[13, 42], who suggested the discovery of a cosmic axis in NR97, which is in agreement with a former theoretical idea already presented in the Gödel cosmology.

It is worth to call attention to the fact that the NR97 conclusions may reconcile an earlier observation of the peculiar orientation of the spin axes of galaxies in the supercluster Perseus-Piscis[43, 42]. Meanwhile, Dobado and Maroto have proposed the effect, if real, may be interpreted through the coupling of the electromagnetic field with a background torsion field created by charged fermions[14].

In this paper we consider the possibility to explain the polarization effect in the framework of scalar-tensor gravity theories which carry torsion. Although a viable proposal, this suggestion should put forward further to compare with the observational implications of the existence of such a chiral background of relic particles to support the idea. This crucial constraint was overlooked. Thus, in our considerations, a screwed cosmic strings is able to create a propagating effect which may manifest outside the string itself. In this sense, being the effect a real one, this model may also provide a consistent description of the NR97 conclusions with torsion.

If the cosmological anisotropy that Nodland and Ralston[3] have claimed to exist in the direction $\hat{s} = ([21 \pm 2]hrs, 0^0 \pm 20^0) \ (r.a.,dec.)$ and the optical activity of the Hutsemékers and Lamy[2] to the quasar polarization vectors are real, then it follows that our theory is able to provide a consistent explanation for the occurrence of this phenomenon in the propagation of electromagnetic waves over cosmic distances. Concommitantly, the theory can account also for the peculiar alignment observed in some supercluster of galaxies[42, 13], which is a potential indication of the existence of a universal torsion (or shear) field and an universal spin, as well.

We consider, as a possible origin of such effect, the coupling between electromagnetic fields and some screwed cosmic string background in scalar-tensor gravity theories, without fermion filed, given by (3.1). The use of an alternative gravity theories is justified by the fact that Einstein gravitation cannot explain these questions. In this approach the screwed cosmic string background can be source of optical activity even if it has no spin. In screwed cosmic string background the medium can be birefringent too and it has electromagnetic radiation interaction by Chern-Simons coupling with scalar gradient. In this way, we can explain the optical activity without considering that the fermionic matter is the source of optical activity and torsion, as considered by other authors [14].

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