SPUN PLASMA MODEL FOR COSMOLOGICAL EVOLUTION AND EINSTEIN CARTAN EVANS (ECE) UNIFIED FIELD THEORY.

by

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ABSTRACT

A simple plasma model for cosmological evolution is considered by using an electron gas superimposed on spinning space-time. This model is based directly on the relativistic inverse Faraday effect in a well defined limit of Einstein Cartan Evans (ECE) field theory. The spinning space-time of ECE field theory occurs in addition to the well known curving space-time of the Einstein Hilbert field theory of gravitation and causes an electron ensemble of the primordial plasma to spin, producing a well defined angular velocity and angular momentum. The latter is proportional to the primordial spin field, $\underline{B}^{(3)}$, a magnetic flux density originating in the existence of primordial charge and the spinning of space-time. Pulsar radiation for example, is produced by the spinning electrons in the ultra-relativistic limit. Under well defined conditions, the spiral arms of a galaxy may be produced from this model, as well as the central bulge region..

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1. INTRODUCTION

In this paper the Einstein Cartan Evans (ECE) field theory {1-12} is applied in a well defined limit to produce a simple plasma model for cosmological evolution {13}. The model is based directly on the inverse Faraday effect (IFE) as described by the relativistic Hamilton Jacobi (HJ) equation for electrons of a primordial plasma spun by space-time. The spinning space-time is the direct analogy of the circularly polarized electromagnetic field of the IFE. In ECE theory the electromagnetic field is also the spinning of space-time within a proportionality factor $A^{(0)}$, where $cA^{(0)}$ has the S.I. units of volts. In Section 2 the HJ equation is derived as a limit of the ECE wave equation {1-12}, which is a direct consequence of the fundamental tetrad postulate {14} of Cartan or differential geometry. The HJ equation is solved analytically {1-12} to give the dynamics of a primordial plasma of electrons spun by space-time. In order for the primordial plasma to evolve {13} into a universe made up of atoms and molecules, there must also be present primordial protons and neutrons. If the quark model is accepted, the primordial condition of the plasma universe must be described in terms of quarks. However in the simple model given here, consideration is restricted to electrons in order to demonstrate the key principles. In section 3 it is shown that in well defined circumstances the spiral arms of a galaxy may evolve from this spinning plasma model.

2. RELATIVISTIC HAMILTON-JACOBI EQUATION FOR A SPUN ELECTRON PLASMA.

The HJ equation for a spun electron plasma is obtained in a well defined limit of the ECE wave equation {1-12}:

$$(\Box + kT)\, q^a_\mu = 0 \quad -(1)$$

where q^a_μ is the Cartan tetrad, k is Einstein's constant and T is the scalar value of the canonical energy-momentum density. In ECE theory T is always defined for the unified field by:

$$R = -kT \quad -(2)$$

where the scalar curvature R is defined by {1-12}:

$$R = q^\lambda_a \partial^\mu \left(\Gamma^\nu_{\mu\lambda} q^a_\nu - \omega^a_{\mu b} q^b_\lambda \right). \quad -(3)$$

Here $\omega^a_{\mu b}$ is the spin connection and $\Gamma^\nu_{\mu\lambda}$ is the general gamma connection of Cartan geometry {14}, i.e. standard differential geometry available for example in Maple.

The HJ equation is obtained in the limit:

$$kT = \left(\frac{mc}{\hbar}\right)^2 = \frac{kmc}{V} \quad -(4)$$

where the right hand side is the inverse square Compton wavelength:

$$\lambda_c = \frac{\hbar}{mc} \quad -(5)$$

of any particle, including the photon. Here $\hbar$ is the reduced Planck constant, c is the velocity of light and m is the particle mass. Eq. (4) shows that the particle always has a finite volume V {1-12}:

$$V = \frac{k\hbar^2}{mc} \quad -(6)$$

and so there are no point particles in nature. In the limit (4) the ECE wave equation becomes:

$$\left(\Box + \left(\frac{mc}{\hbar} \right)^2 \right) q^a_\mu = 0. \quad -(7)$$

It has been shown {1-12} that this is the Dirac equation for a fermion. Using the ECE postulate:

$$A^a_\mu = A^{(0)} q^a_\mu \quad -(8)$$

the limit (4) gives the Proca equation for the photon with mass (a boson):

$$\left(\Box + \left(\frac{mc}{\hbar} \right)^2 \right) A^a_\mu = 0. \quad -(9)$$

Using the fundamental quantum equivalence rules:

$$p^\mu = i\hbar \partial^\mu \quad -(10)$$

Eq. (7) becomes for each index a the well known Einstein equation of special relativity:

$$p^\mu p_\mu = m^2 c^2. \quad -(11)$$

The HJ equation is obtained finally using the minimal prescription:

$$p^\mu \rightarrow p^\mu + eA^\mu \quad -(12)$$

so we obtain:

$$(p^\mu + eA^\mu)(p_\mu + eA_\mu) = m^2 c^2. \quad -(13)$$

The spun electron plasma in the simple model of this paper is described from an analytical solution {1-12} of Eq. (13). In the limit (4) the various individual fields making up the ECE unified field become independent, so in this limit the spun plasma is independent of gravitation. To describe its interaction with gravitation the field equations of ECE must be used {1-12} and the effect of rotation (Cartan torsion) on translation (Cartan curvature) fully considered. It is also possible to do this by adding terms to T, so that it includes contributions from each field, and from interactions between fields. The basis of the model of the spun primordial plasma used in this paper is that the spin is given by primordial Cartan torsion, which produces a rotating potential A^μ in the minimal prescription (12). This is the same model as the relativistic description of the IFE {1-12}. In the latter, the spin is imparted by a circularly polarized electromagnetic field, i.e. by spinning space-time in the laboratory using a radio frequency field or laser field. In the evolution of a cosmological plasma, the same HJ equation imparts spin through the primordial spinning of space-time. The charge needed for the production of A^μ is the primordial charge on the electron, -e, a universal and assumed unchanging constant. So -e is assumed to be not affected by evolution and is thus primordial.

Solving the HJ equation (13) produces {1-12} the tangential velocity components:

$$v_x = \frac{ec}{m\omega} B^{(0)} \cos \omega t \quad -(14)$$

$$v_y = -\frac{ec}{m\omega} B^{(0)} \sin \omega t \quad -(15)$$

and the radial vector components

$$r_x = -\frac{ec^2 B^{(0)}}{\gamma \omega^2} \sin \omega t \quad -(16)$$

$$r_y = -\frac{ec^2 B^{(0)}}{\gamma \omega^2} \cos \omega t \quad -(17)$$

Here ω is the angular frequency of the primordial spin, i.e. the angular frequency of the spin of space-time, -e is the charge on the electron, m is its mass, and $B^{(0)}$ is the magnitude of the primordial ECE spin field:

$$\underline{B}^{(3)} = B^{(0)} \underline{k} . \quad -(18)$$

This is a primordial magnetic flux density {1-12} produced again by the primordial spinning of space-time itself. The charge -e, the unchanging universal constant, produces the $\underline{B}^{(3)}$ field from this primordial spin via the spinning potentials of Eq. (12). This is again in precise analogy with the IFE, in which the magnetization of an electron ensemble is produced by the spin field $\underline{B}^{(3)}$ of a laser or radio frequency field. The factor γ is defined {1-12} by:

$$\gamma = mc \left(1 + \left(\frac{eB^{(0)}}{m\omega} \right)^2 \right)^{1/2} . \quad -(19)$$

The angular velocity Ω of one electron of the primordial plasma is:

$$\Omega = \frac{d\theta}{dt} = \frac{v}{r} = \left(\frac{v_X^2 + v_Y^2}{r_X^2 + r_Y^2} \right)^{1/2} \quad -(20)$$

where θ is the angular displacement in radians and where v is the magnitude of the tangential velocity. From Eqs. (14) to (20):

$$\Omega = \left(\omega^2 + \frac{e^2 B^{(0)2}}{m^2} \right)^{1/2} \quad -(21)$$

so that there is a contribution to it from the angular frequency ω and from $B^{(0)2}$. In the applied electromagnetic field of the IFE, the latter is proportional to beam intensity. Eq (21) gives the angular velocity of a spinning electron of a primordial plasma due to the angular velocity

ω of the primordial spinning space-time.

In a spiral galaxy {15} the tangential velocity of the arms is constant, so the relation between θ and r in that region is a hyperbolic spiral:

$$\theta = \text{constant} / r. \quad -(22)$$

It is considered in the simple plasma model of this paper that the central bulge of the galaxy is described by the dynamics of the spinning plasma, Eq. (21). In these dynamics the relation between the angular displacement and the radial vector is given by:

$$\theta = \int \frac{v}{r}\, dt, \quad \frac{1}{r} = \frac{1}{v}\left(\omega^2 + \frac{e^2 B^{(0)2}}{m^2}\right)^{1/2}. \quad -(23)$$

This evolves into the spiral arms when the sum:

$$v = r\left(\omega^2 + \frac{e^2 B^{(0)2}}{m^2}\right)^{1/2} \quad -(24)$$

becomes constant. This limit is considered further in Section 3.

In the rotating plasma (central bulge) the angular momentum is given by:

$$J_Z = m\left(r_X v_Y - r_Y v_X\right). \quad -(25)$$

If the rotation is considered to be taking place about the $\underline{k}$ axis:

$$\underline{J} = J_Z \underline{k} = \frac{e^2 c^3 B^{(0)2}}{\gamma \omega^3} \underline{k} \quad -(26)$$

and this rotation defines the magnetic dipole moment though the gyromagnetic ratio of the electron:

$$\underline{m} = -\frac{e}{2m} \underline{J} \quad -(27)$$

The energy magnitude due to this motion is therefore:

$$|En| = mB^{(0)} = \frac{e^3 c^3 B^{(0)3}}{2m\gamma\omega^3} \quad -(28)$$

and is the magnitude or modulus of the torque:

$$\underline{Tq} = \underline{m} \times \underline{B}. \quad -(29)$$

The angular momentum may be expressed in terms of the $\underline{B}^{(3)}$ field as:

$$\underline{J}^{(3)} = \frac{e^2 c^2}{\omega^2} \left(\frac{B^{(0)}}{(m^2\omega^2 + e^2 B^{(0)2})^{1/2}} \right) \underline{B}^{(3)}. \quad -(30)$$

This expression is one of special relativity: it describes the relativistic spinning of an electron of a primordial electron plasma spun by space-time itself. The spinning electron radiates {15} and in the ultra - relativistic limit this is well known to produce synchrotron radiation - the radiation from a pulsar. The ultra - relativistic limit can be considered to be the high frequency limit {1-12}:

$$\omega \gg \frac{eB^{(0)}}{m} \quad -(31)$$

when Eq. (30) reduces to:

$$\underline{J}^{(3)} = \left(\frac{e^2 c^2}{m\omega^3} \right) B^{(0)} \underline{B}^{(3)}. \quad -(32)$$

In the opposite low frequency limit:

$$\omega \ll \frac{eB^{(0)}}{m} \quad -(33)$$

Eq. (30) reduces to:

$$\underline{J}^{(3)} = \frac{ec^2}{\omega^2}\underline{B}^{(3)} . \quad -(34)$$

In the IFE analogously {1-12}, Eq. (32) describes a high frequency laser and Eq. (34) a low frequency radio field. Therefore the angular momentum of a pulsar originates from the primordial $\underline{B}^{(3)}$ of spinning space-time acting upon a primordial plasma. For simplicity this has been considered to be an electron plasma, i.e. an ensemble of N electrons. The complete N electron result is {1-12}

$$\underline{B}^{(3)}_{plasma} = \frac{N}{V}\frac{\mu_0 e^3 c^2}{2m\omega^2}\left(\frac{B^{(0)}}{\left(m^2\omega^2 + e^2 B^{(0)2}\right)^{1/2}}\right)\underline{B}^{(3)} \quad -(35)$$

where V is the volume occupied by the N electrons. The $\underline{B}^{(3)}_{plasma}$ field within the plasma is seen to be different from the primordial $\underline{B}^{(3)}$ Field. In direct analogy, the $\underline{B}^{(3)}$ field induced by the IFE in N electrons occupying a volume V is different from the free space $\underline{B}^{(3)}$ field of the laser or RF field. In the well known plasma model of the universe {13} a spiral galaxy evolves out of a pulsar. The latter emits pulses of electromagnetic radiation at regular intervals as is well known {15}.

3. EVOLUTION OF THE SPIRAL ARMS

In the following some models for galaxies are discussed which evolve into certain limiting cases. Basis is the relation between the angular displacement θ and the radial vector r given in Eq. (23). It is assumed that ω and $B^{(0)}$ are not implicitly time dependent. Then from (23) we obtain the basis equation

$$\theta = \tau \left(\omega^2 + \left(\frac{eB^{(0)}}{m} \right)^2 \right)^{1/2} \quad (36)$$

where τ is the evolution time of the part of the galaxy or primordial plasma volume under consideration .

3.1 Ultra-relativistic Limit

Assuming

$$\omega \gg \frac{eB^{(0)}}{m} \quad (37)$$

and a constant tangential velocity v_0 with

$$\omega = \frac{v_0}{r} \quad (38)$$

leads to the hyperbolic spiral equation

$$r = \frac{v_0 \tau}{\theta} \quad (39)$$

This limit is the ultra-relativistic case where spinning spacetime is the only driving part of motion. It has been discussed in paper 76 that this type of spiral fits well to existing spiral galaxies. Different scale factors have to be used for different galaxy arms, resulting in differing values for the time evolution parameter τ. This can be interpreted as a varying age of the spiral arms. Fig. 1 shows some examples which also demonstrate the asymptotic behaviour of hyperbolic spirals.

3.2 Non-relativistic Limit

In the center of the bulge it can be assumed that the magnetic induction $B^{(0)}$ predominates compared to the angular velocity ω of the primordial spin:

$$\frac{eB^{(0)}}{m} \gg \omega . \qquad (40)$$

Under this condition we obtain for the angular displacement:

$$\Theta = \frac{eB^{(0)}}{m} \tau . \qquad (41)$$

There is no radius dependence if $B^{(0)}$ is constant. The primordial plasma moves on circles in the central part of the bulge. In some distance from the center, spin effects begin to contribute. Then Eq. (36) can be written as

$$\Theta = \frac{eB^{(0)}}{m} \tau \left(x+1\right)^{1/2} \qquad (42)$$

with

$$x = \left(\frac{mv_0}{eB^{(0)}} \frac{1}{r}\right)^2 . \qquad (43)$$

In case of x<<1 this expression can be developed into a series

$$\Theta = \frac{eB^{(0)}}{m} \tau \left(1 + \frac{x}{2} - \frac{x^2}{8} + \frac{x^3}{16} - \ldots\right) \qquad (44)$$

which represents a superposition of spirals of different type. Restricting the series to the linear term gives

$$\begin{aligned}\Theta &= \frac{eB^{(0)}}{m} \tau \left(1 + \frac{1}{2}\left(\frac{mv_0}{eB^{(0)}} \frac{1}{r}\right)^2\right) \qquad (45)\\ &= \frac{eB^{(0)}}{m} \tau + \frac{1}{2} v_0^2 \tau \frac{1}{r^2}\end{aligned}$$

which can be rewritten to

$$r = V_0 \left(2 \left(\frac{\theta}{\tau} - \frac{eB^{(0)}}{m} \right) \right)^{-1/2} \tag{46}$$

This is an equation of a spiral of type

$$r = \frac{a}{\sqrt{\theta - b}} \tag{47}$$

with constants a and b. Examples are shown in Fig. 2. There is an asymptote in the outer region.

3.3 Intermediate Range

After having discussed both ends of the scale (ultra-relativistic and non-relativistic), we investigate two models where

$$\omega \approx \frac{eB^{(0)}}{m} \tag{48}$$

3.3.1 $B^{(0)}$ is constant

From Eq. (36) we obtain

$$\theta^2 = \tau^2 \left(\omega^2 + \left(\frac{eB^{(0)}}{m} \right)^2 \right) \tag{49}$$

Assuming again a constant orbital velocity (Eq. (38)) leads to

$$\theta^2 = \left(\frac{V_0 \tau}{r} \right)^2 + \left(\frac{eB^{(0)}}{m} \tau \right)^2 \tag{50}$$

which can be rewritten to

$$r = V_0 \tau \left(\theta^2 - \left(\frac{eB^{(0)}}{m} \tau \right)^2 \right)^{-1/2} \tag{51}$$

This is a spiral of similar type as Eq. (47):

$$r = \frac{a}{\sqrt{\theta^2 - b}} \quad . \tag{52}$$

3.3.2 $B^{(0)}$ is proportional to 1/r

Now we assume additionally that the magnetic induction field is dependent on r. This is reasonable since this field plays a dominant role in the central bulge but not in the exterior galaxy arms. We try the ansatz

$$\frac{e}{m} B^{(0)} = \frac{v_1}{r} \tag{53}$$

with v_1 being a constant having physical dimensions of a velocity. Then (49) leads to

$$\theta^2 = \left(\frac{v_0 + v_1}{r} \tau \right)^2 \tag{54}$$

which is identical to

$$r = \frac{v_0 + v_1}{\theta} \tau \quad . \tag{55}$$

Again this is a hyperbolical spiral. This means that there is a smooth transition from the central bulge in the galaxy to the outer spiral arms. This confirms the consistency of the model. Examples are shown in Fig. 3. The spirals are similar to those of Fig.1, with exception of some asymptotes which, however, are outside the validity range of the models in Fig. 3.

In total we obtain the following picture. The primordial plasma moves circularly near to the center of the bulge. At some distance from that it spirals out until reaching the border of the central bulge. There it passes into hyperbolic spirals which represent the outer form of the galaxy. All this is based on a pure electronic plasma model. More realistic models would have to take into account protons and other charged atoms. However the electrons bear the most kinetic energy in the plasma , insofar the models used in this paper are justified.

Finally the results are compared to two images of galaxies. Fig. 4 is a reworked photo ("sketch") of the Wirlpool galaxy. The spiral arms run nearly in parallel in a significant range of angles. This is similar to Fig. 1 in the area r<1. The hyperbolic character is well visible. For most galaxies the central bulge has no structure on astronomic photographs due to the high star and plasma densities therein. An exception is the galaxy NGC1300 (Fig. 5). If we identify the barred region with the central bulge, some spiralling structures are visible therein, validating our model. In addition, the bright dot at the center may be interpreted as the part where a circular motion is predicted. So the simple models presented in this paper, which are based on special relativity enriched by Cartan torsion, seem to describe certain structures of the visible cosmos.

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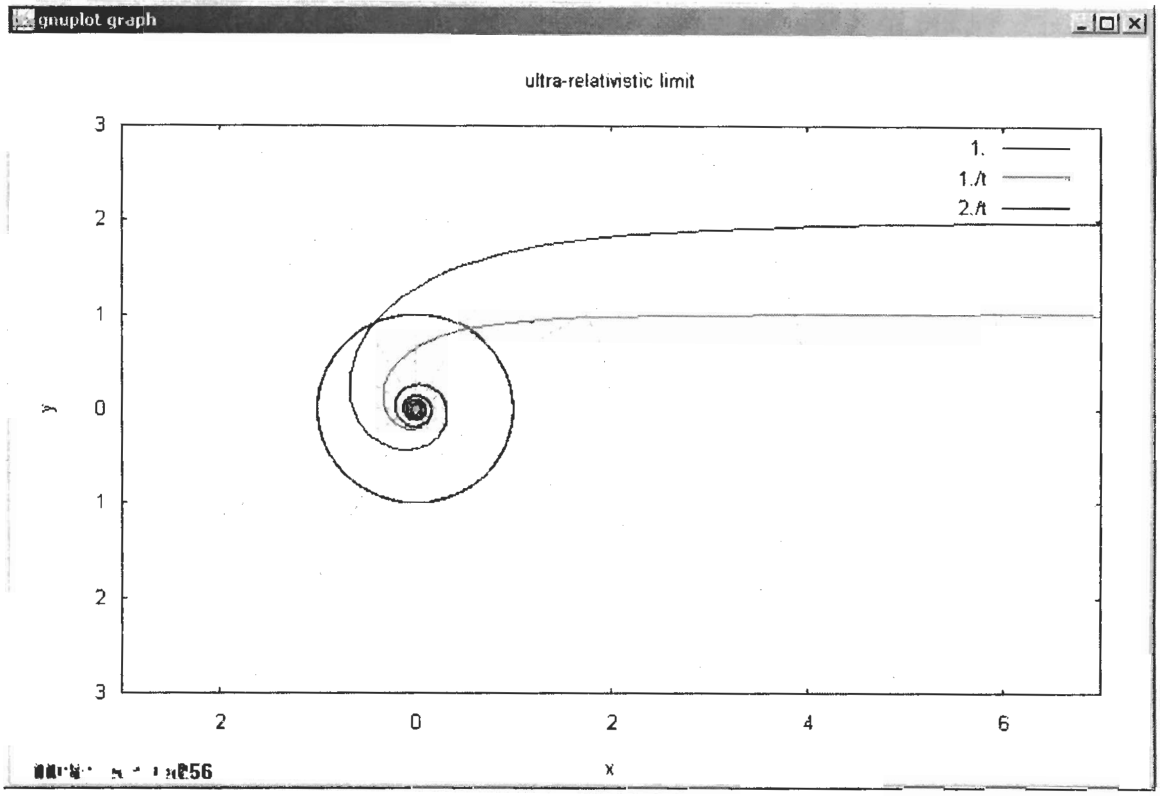

Fig. 1. Spiral models of ultra-relativistic limit.

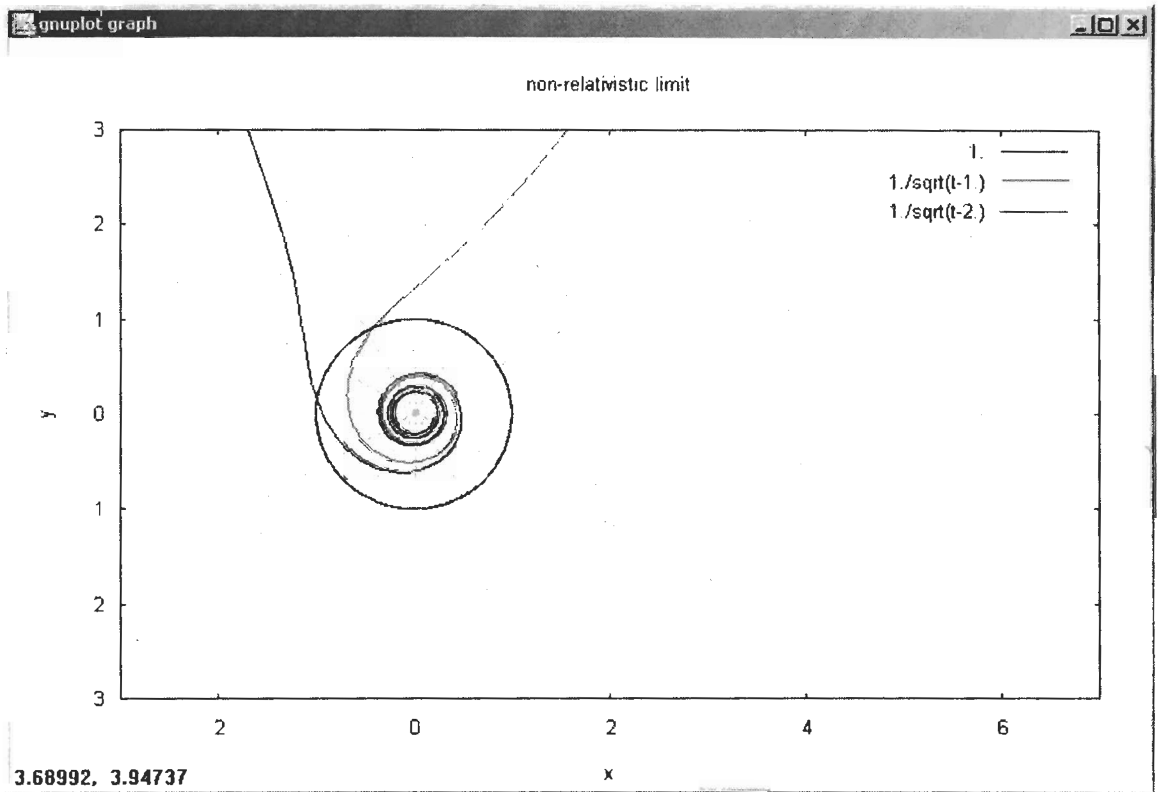

Fig. 2. Spiral models of non-relativistic limit.

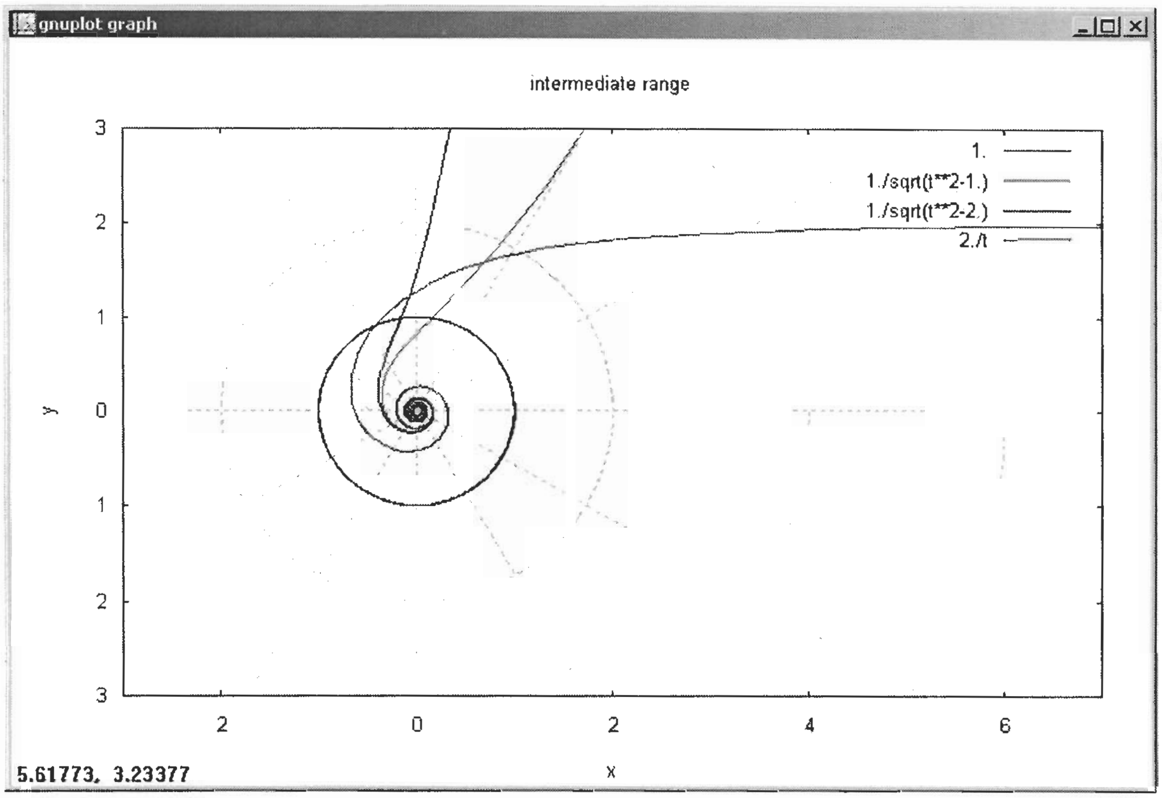

Fig. 3. Spiral models for the intermediate range (transition central bulge – spiral arms).

Fig. 4. Whirlpool galaxy M51.

Fig. 5. Barred spiral galaxy NGC1300.