THE SHIVERING (ZITTERBEWEGUNG) INDUCED BY THE VACUUM OF THE ELECTRIC DIPOLE POTENTIAL AND FIELD.

by

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ABSTRACT

The well known zitterbewegung (shivering) theory of the Lamb shift in quantum mechanics is adapted for classical electrostatics within the structure of the ECE2 unified field theory. A simple and new fundamental postulate replaces the position vector $\underline{r}$ wherever it occurs by $\underline{r} + \delta\underline{r}$, where $\delta\underline{r}$ is the fluctuation or shivering induced by the vacuum. Using this postulate the well known dipole potential and electric field strength of electrostatics are calculated using the type of ensemble averaging used in the accurate shivering theory of the Lamb shift.

Keywords: ECE2 theory, zitterbewegung or shivering induced by the vacuum.

UFT393

1. INTRODUCTION

In recent papers of this series {1 - 41} the law of conservation of antisymmetry has been inferred and vacuum effects of various kinds mapped with the spin connection, antisymmetry being rigorously conserved. In the preceding paper UFT392 the well known zitterbewegung (shivering) theory of the influence of the vacuum was introduced into ECE2 unified field theory. In this paper the ensemble averaged dipole potential and electric field strength of electrostatics are calculated in the presence of shivering due to the vacuum. It is found that the vacuum produces an intricate structure which is wholly unknown in the standard model of macroscopic electrodynamics

This paper is a short synopsis of detailed calculations given in the notes accompanying UFT393 on www.aias.us and www.upitec.org. Note 393(1) is the calculation of the mean spin connection due to the vacuum for the Coulomb field of one electron. Note 393(2) calculates the shivering Coulombic electric field strength and discusses the conservation of scalar antisymmetry. Some discussion is given of the calculation of the mean square fluctuation using mode theory and the statistical mechanics of the vacuum. Note 393(3) is a preliminary calculation of the shivering electric dipole field. Section 2 of this paper is based on Notes 393(4) to 393(6), and gives the ensemble averaged shivering electric dipole potential and field strength.

Section 3 is a numerical and graphical development of Section 2.

2. THE SHIVERING DIPOLE POTENTIAL AND FIELD STRENGTH

With reference to Note 393(4) the calculation of the dipole electric field strength $\underline{E}_0$ from the dipole potential ϕ_0 is given in all detail. This is a baseline calculation which is extended to included vacuum effects. The dipole potential in the hypothetical absence of the vacuum is the well known:

$$\underline{\phi}_0 = \frac{1}{4\pi\epsilon_0 r^3} \underline{r} \cdot \underline{p} \quad -(1)$$

where:

$$\underline{r} = \underline{x} - \underline{x}_0 \quad -(2)$$

and

$$|\underline{r}| = |\underline{x} - \underline{x}_0|. \quad -(3)$$

The dipole moment $\underline{p}$ is an intrinsic property of the charge distribution in for example a molecule. Here ϵ_0 is the vacuum permittivity. The dipole electric field strength $\underline{E}_0$ in volts per metre at point $\underline{x}$ due to a dipole moment $\underline{p}$ at point $\underline{x}_0$ is:

$$\underline{E}_0 = -\underline{\nabla}\phi_0. \quad -(4)$$

Therefore:

$$\underline{E}_0 = -\frac{1}{4\pi\epsilon_0} \underline{\nabla} \left(\frac{\underline{r} \cdot \underline{p}}{r^3} \right). \quad -(5)$$

The gradient is most clearly worked out using Cartesian coordinates as detailed in Note 393(4)

$$\underline{E}_0 = -\frac{1}{4\pi\epsilon_0} \frac{\partial}{\partial X} \left(\frac{X p_X + Y p_Y + Z p_Z}{(X^2 + Y^2 + Z^2)^{3/2}} \right) \underline{i} + \dots \quad -(6)$$

so:

$$\underline{E}_0 = \frac{1}{4\pi\epsilon_0 r^3} \left(\frac{3\underline{r}(\underline{p} \cdot \underline{r})}{r^2} - \underline{p} \right). \quad -(7)$$

The effect of the vacuum is introduced using a simple new axiom:

$$\mathbf{r} \rightarrow \mathbf{r} + \delta\mathbf{r}. \quad - (8)$$

So $\mathbf{r}$ is replaced by $\mathbf{r} + \delta\mathbf{r}$ wherever the former occurs. Here $\delta\mathbf{r}$ is the shivering or zitterbewegung term due to the influence of the vacuum. The latter is always present, so the complete theory of classical electrodynamics must always consider Eq. (8). This is true for the whole of physics. For example, the position vector is:

$$\mathbf{r} = X\mathbf{i} + Y\mathbf{j} + Z\mathbf{k} \quad - (9)$$

so:

$$X \rightarrow X + \delta X \quad - (10)$$
$$Y \rightarrow Y + \delta Y \quad - (11)$$
$$Z \rightarrow Z + \delta Z \quad - (12)$$

The effect of the vacuum on the $\boldsymbol{\nabla}$ operator is given by:

$$\boldsymbol{\nabla} \rightarrow \frac{\partial}{\partial(X+\delta X)}\mathbf{i} + \frac{\partial}{\partial(Y+\delta Y)}\mathbf{j} + \frac{\partial}{\partial(Z+\delta Z)}\mathbf{k}. \quad - (13)$$

The dipole moment $\mathbf{p}$ has no intrinsic dependence on X, Y, and Z because by definition, the dipole moment is a fundamental molecular property listed for examples in the tables of standard laboratories. So the dipole moment is not affected by the vacuum, and in the calculation leading to Eq. (7), the dipole moment is a constant.

Therefore the shivering dipole potential is:

$$\phi = \frac{1}{4\pi\epsilon_0 |\mathbf{r} + \delta\mathbf{r}|^3} (\mathbf{r} + \delta\mathbf{r}) \cdot \mathbf{p} \quad - (14)$$

where:

$$|\underline{r} + \delta\underline{r}| = \left((\underline{r} + \delta\underline{r}) \cdot (\underline{r} + \delta\underline{r}) \right)^{1/2}$$

$$= r \left(1 + \frac{2\underline{r} \cdot \delta\underline{r}}{r^2} + \frac{\delta\underline{r} \cdot \delta\underline{r}}{r^2} \right)^{1/2} \quad -(15)$$

So:

$$|\underline{r} + \delta\underline{r}|^3 = r^3 \left(1 + \frac{2\underline{r} \cdot \delta\underline{r}}{r^2} + \frac{\delta\underline{r} \cdot \delta\underline{r}}{r^2} \right)^{3/2} . \quad -(16)$$

Similarly the shivering dipole electric field strength is:

$$\underline{E} = \frac{1}{4\pi\epsilon_0} \left(\frac{3(\underline{r} + \delta\underline{r})(\underline{p} \cdot (\underline{r} + \delta\underline{r}))}{|\underline{r} + \delta\underline{r}|^5} - \frac{\underline{p}}{|\underline{r} + \delta\underline{r}|^3} \right) . \quad -(17)$$

By conservation of scalar antisymmetry {1 - 12}:

$$\underline{E} = -\underline{\nabla}\phi = -\underline{\nabla}\phi_0 + \underline{\omega}\phi_0 = -\frac{\partial \underline{A}_0}{\partial t} - \omega_0 \underline{A}_0 \quad -(18)$$

in which $\underline{A}_0$ is the electric vector potential in the hypothetical absence of the vacuum, and where:

$$\omega^\mu = \left(\frac{\omega_0}{c}, \underline{\omega} \right) \quad -(19)$$

is the spin connection four vector or "vacuum map" of ECE2 unified field theory. Therefore:

$$\underline{E} = \underline{E}_0 + \underline{\omega}\phi_0 \quad -(20)$$

is the experimentally observed electric field strength in the presence of the ubiquitous vacuum. The spin connection, or vacuum map, is always observed experimentally. Similarly the Lamb shift and other radiative corrections are always observed and are always present.

Standard model classical electrodynamics ignores the effect of the vacuum, and ignores half of physics.

Following the well known {1 - 12} theory of the Lamb shift the ensemble averaged potential and field strength must be calculated because $\delta \underline{r}$ is a fluctuating property of the vacuum. Denoting:

$$x := \frac{1}{r^2}\left(2\underline{r}\cdot\delta\underline{r} + \delta\underline{r}\cdot\delta\underline{r}\right) \quad -(21)$$

then:

$$\phi = \frac{(\underline{r}+\delta\underline{r})\cdot\underline{p}}{4\pi\epsilon_0 r^3 (1+x)^{3/2}} \quad -(22)$$

and

$$\underline{E} = \frac{1}{4\pi\epsilon_0}\left(\frac{3(\underline{r}+\delta\underline{r})(\underline{p}\cdot(\underline{r}+\delta\underline{r}))}{r^5(1+x)^{5/2}} - \frac{\underline{p}}{r^3(1+x)^{3/2}}\right). \quad -(23)$$

In an isotropic vacuum:

$$\langle \delta\underline{r} \rangle = \underline{0} \quad -(24)$$

but

$$\langle \delta\underline{r}\cdot\delta\underline{r} \rangle \neq 0. \quad -(25)$$

For:

$$x \ll 1 \quad -(26)$$

the binomial expansion gives:

$$(1+x)^n = 1 + nx + \frac{n(n-1)}{2!}x^2 + \cdots \quad -(27)$$

so:

$$(1+x)^{-3/2} = 1 - \frac{3x}{2} + \frac{15}{8}x^2 + \cdots \quad -(28)$$

and

$$(1+x)^{-5/2} = 1 - \frac{5x}{2} + \frac{35}{8}x^2 + \cdots \quad -(29)$$

It follows that:

$$\phi \sim \frac{(\underline{r} + \delta\underline{r}) \cdot \underline{p}}{4\pi\epsilon_0 r^3}\left(1 - \frac{3x}{2} + \frac{15x^2}{8} + \cdots\right) \quad -(30)$$

and

$$\underline{E} = \frac{1}{4\pi\epsilon_0}\left(\frac{3(\underline{r}+\delta\underline{r})(\underline{p}\cdot(\underline{r}+\delta\underline{r}))}{r^5}\left(1 - \frac{5x}{2} + \frac{35}{8}x^2 + \cdots\right) - \frac{\underline{p}}{r^3}\left(1 - \frac{3x}{2} + \frac{15x^2}{8} + \cdots\right)\right) \quad -(31)$$

To first order in x:

$$\langle\phi\rangle = \frac{1}{4\pi\epsilon_0 r^3}\left(\underline{r}\cdot\underline{p} + \langle\delta\underline{r}\cdot\underline{p}\rangle\right) - \frac{3\underline{p}}{8\pi\epsilon_0 r^5} \cdot \left\langle(\underline{r}+\delta\underline{r})(2\underline{r}\cdot\delta\underline{r} + \delta\underline{r}\cdot\delta\underline{r})\right\rangle \quad -(32)$$

By vacuum isotropy:

$$\langle\delta\underline{r}\cdot\underline{p}\rangle = 0. \quad -(33)$$

In Eq. (32):

$$\langle (\underline{r}+\delta\underline{r})(2\underline{r}\cdot\delta\underline{r}+\delta\underline{r}\cdot\delta\underline{r})\rangle$$

$$= \underline{i}\left\langle (x+\delta x)\left(2(x\,\delta x+y\,\delta y+z\,\delta z)+\delta x^2+\delta y^2+\delta z^2\right)\right\rangle \quad -(34)$$

$$+ \cdots$$

By vacuum isotropy:

$$\langle \delta x\,\delta y\rangle = \langle \delta x\,\delta z\rangle = \langle \delta y\,\delta z\rangle = 0 \quad -(35)$$

so

$$\langle (\underline{r}+\delta\underline{r})(2\underline{r}\cdot\delta\underline{r}+\delta\underline{r}\cdot\delta\underline{r})\rangle = \frac{5\underline{r}}{3}\langle \delta\underline{r}\cdot\delta\underline{r}\rangle. \quad -(36)$$

Therefore to first order in x the shivering dipole potential is:

$$\langle \phi\rangle = \frac{\underline{p}\cdot\underline{r}}{4\pi\epsilon_0 r^3}\left(1-\frac{5}{2r^2}\langle \delta\underline{r}\cdot\delta\underline{r}\rangle\right) \quad -(37)$$

The standard model dipole potential is given in Eq. (1).

The potential energy from the vacuum is given from the mean square displacement term. Therefore energy can be transferred from the vacuum, aether or spacetime to a circuit as in UFT311, UFT321, UFT364, UFT382 and UFT383 on www.aias.us and www.upitec.org. The mean square vacuum fluctuation can be calculated or computed as in Note 393(2) from mode theory or from statistical mechanics. The result for the Lamb shift gives an accurate agreement with experimental data. So there can be great confidence in the shivering or zitterbewegung theory extended to the whole of physics.

After a long but straightforward calculation given in all detail in Note 393(6), it is found that the shivering dipole electric field strength is:

$$\langle \underline{E} \rangle = \frac{1}{4\pi\epsilon_0 r^3}\left(\frac{3\underline{r}(\underline{p}\cdot\underline{r})}{r^2} - \underline{p} \right)$$

$$- \frac{1}{4\pi\epsilon_0 r^5}\langle \delta\underline{r}\cdot\delta\underline{r} \rangle \left(\frac{35}{2}\frac{\underline{r}}{r^2}(\underline{p}\cdot\underline{r}) - \frac{5}{2}\underline{p} \right)$$

$$- \frac{5}{8\pi\epsilon_0 r^7}\langle \delta\underline{r}\cdot\delta\underline{r} \rangle^2 \underline{p} + \cdots \quad -(38)$$

This was evaluated by computer algebra, using code to work out the isotropic averages.

A very rich new physics emerges.

In general these calculations must be carried out with computer algebra to eliminate or minimize human error and in order to compute higher order terms in the binomial expansion. The calculations of Notes 393(5) and 393(6) are checked by computer algebra in Section 3, and sample results graphed.

3. COMPUTATION AND GRAPHICS

(Section by Dr. Horst Eckardt)

The shivering (Zitterbewegung) induced by the vacuum of the electric dipole potential and field

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3 Computation and graphics

The expansion factor x for the dipole potential and field has been used in Eqs. (22-31). It has been shown that the averaged values in linear approximation of x are

$$\langle\phi\rangle = \frac{\mathbf{p}\cdot\mathbf{r}}{4\pi\epsilon_0 r^3}\left(1-\frac{5}{2\,r^2}\langle\delta\mathbf{r}\cdot\delta\mathbf{r}\rangle\right), \tag{39}$$

$$\begin{aligned}\langle\mathbf{E}\rangle = &\frac{1}{4\pi\epsilon_0 r^3}\left(\frac{3\mathbf{r}(\mathbf{p}\cdot\mathbf{r})}{r^2}-\mathbf{p}\right)\\ &-\frac{1}{4\pi\epsilon_0 r^5}\langle\delta\mathbf{r}\cdot\delta\mathbf{r}\rangle\left(\frac{35\,\mathbf{r}(\mathbf{p}\cdot\mathbf{r})}{2\,r^2}-\frac{5}{2}\mathbf{p}\right).\end{aligned} \tag{40}$$

This gives quadratic corrections, i.e. in proportion to $\langle\delta\mathbf{r}\cdot\delta\mathbf{r}\rangle$. In additon, a fourth-order term appears being in proportion to the dipole moment only:

$$\langle\mathbf{E}\rangle \to \langle\mathbf{E}\rangle - \frac{5}{8\pi\epsilon_0 r^7}\left\langle(\delta\mathbf{r}\cdot\delta\mathbf{r})^2\right\rangle\mathbf{p}. \tag{41}$$

This is, however, not an approximation of fourth order in $\delta\mathbf{r}$. Inclusion of x^2 terms gives several more complicated expressions. The dipole potential in this approximation is

$$\langle\phi\rangle^{(4)} = \frac{\mathbf{p}\cdot\mathbf{r}}{4\pi\epsilon_0 r^3}\left(1-\frac{5}{r^2}\langle\delta\mathbf{r}\cdot\delta\mathbf{r}\rangle-\frac{35}{8\,r^4}\langle\delta\mathbf{r}\cdot\delta\mathbf{r}\rangle^2\right). \tag{42}$$

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Obviously the factor of the quadratic term is changed by the additional terms introduced by x^2. The electric field for this degree of expansion is

$$\begin{aligned}\langle \mathbf{E} \rangle^{(4)} &= \frac{1}{4\pi\epsilon_0 r^3}\left(\frac{3\mathbf{r}(\mathbf{p}\cdot\mathbf{r})}{r^2} - \mathbf{p}\right) \\ &+ \frac{1}{4\pi\epsilon_0 r^7}\left\langle(\delta\mathbf{r}\cdot\delta\mathbf{r})^2\right\rangle \left(\frac{1435\,\mathbf{r}(\mathbf{p}\cdot\mathbf{r})}{24\,r^2} + \frac{35}{24}\mathbf{p} - \frac{35}{3r^2}\begin{bmatrix} X^2 & 0 & 0 \\ 0 & Y^2 & 0 \\ 0 & 0 & Z^2 \end{bmatrix}\mathbf{p}\right) \\ &+ \frac{1}{4\pi\epsilon_0 r^9}\left\langle(\delta\mathbf{r}\cdot\delta\mathbf{r})^3\right\rangle \frac{35}{8}\mathbf{p}.\end{aligned} \tag{43}$$

It is important to note that the quadratic terms of $\delta\mathbf{r}$ completely cancel, leaving terms of fourth and sixth order. It is not possible to write the result in pure vector form, a matrix-vector multiplication with $\mathbf{p}$ is required, or one has to list the components of this expression explicitly.

The results have been graphed for several models of $\delta\mathbf{r}$. In Fig. 1 the undistorted dipole field is shown by field lines and field vector arrows. In Fig. 2 we used a dipole with constantly shifted coordinates: $\delta X = 0.2, \delta Y = -0.2$, according to Eq. (17). This gives a constant shift of the field, however the isotropy conditions like

$$\langle \delta X \rangle = 0 \tag{44}$$

are not fulfilled. Therefore this is only a hypothetical case.

More interesting is the dipole field with quadratic shivering terms according to Eqs. (40, 41) graphed in Fig. 3. It is seen that there is a split of the dipole centre being much larger in size than $|\delta\mathbf{r}|$. The far field is approximately kept intact. Fig. 4 is a magnified plot of the central region. There are two distinct divergences now in addition to the central divergence of the standard dipole field and there is a constriction of field lines near to the centre.

The model has been made more realistic by allowing a spatial variation of the shivering terms δr. We used an approximation

$$\langle \delta r \rangle = \frac{a}{r} \tag{45}$$

with $a = 1$. Now the central region changes as graphed in Fig. 5. The constriction remains but the divergence regions enlarge in scale while being very similar as in Fig. 4 for constant shivering. The scaling could be changed by the value of a. The upper part of the divergent structure is plotted in Fig. 6 in a magnified view. This is not a diverging point but a line in 2D. Extended to 3D by rotation, this represents a charge density "cap". The dipole, which is a mathematical point in the original field, is split up in space to two extended charges.

Finally we included the fourth-order terms of Eq. (43) in the calculation, again with the zitterbewegung model (45). The results (Fig. 7) show two distinct singular points displaced on the X axis. The displacement now is rotated by 90 degrees compared to Fig. 5. This is a ring when the 2D plot is rotated to describe the full 3D field. The field near to the ring is a torus field. Together with the central dipole which is still there, this structure reminds to a d orbital of atomic physics.

To verify the properties of the dipole field structure with shivering, we have computed the divergence and curl of the dipole field in 2D representation. The divergence is

$$\nabla \cdot \mathbf{E} = \frac{\partial E_X}{\partial X} + \frac{\partial E_Y}{\partial Y}, \tag{46}$$

and the curl has only a Z component since $\mathbf{E}$ is planar:

$$(\nabla \times \mathbf{E})_Z = \frac{\partial E_Y}{\partial X} - \frac{\partial E_X}{\partial Y}. \tag{47}$$

The divergence (corresponding to the field in Fig. 8) is graphed in Fig. 9. It becomes effective in the region of the torus-like structure and pertains to the centre as described. The curl of a dipole field is zero. The zitterbewegung, however, evokes a vorticity graphed in Fig. 10. It is restricted to the torus region and zero where the original dipole field dominates. The signs of the curl differ for $X > 0$ and $X < 0$ because the torus field lines have inverse directions on both sides as can be seen from Fig. 8.

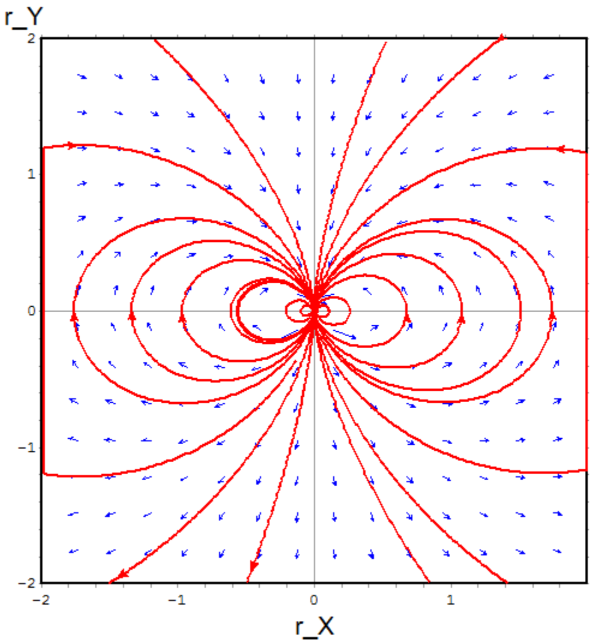

Figure 1: Undistorted dipole field.

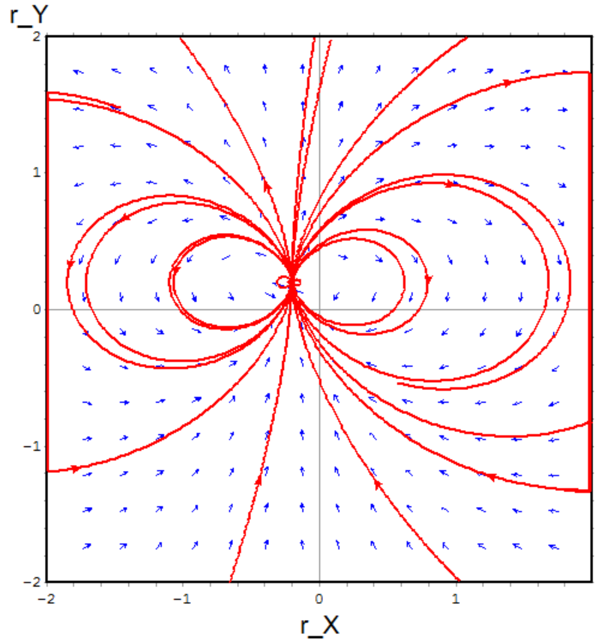

Figure 2: Dipole with constantly shifted coordinates: $\delta X = 0.2$, $\delta Y = -0.2$.

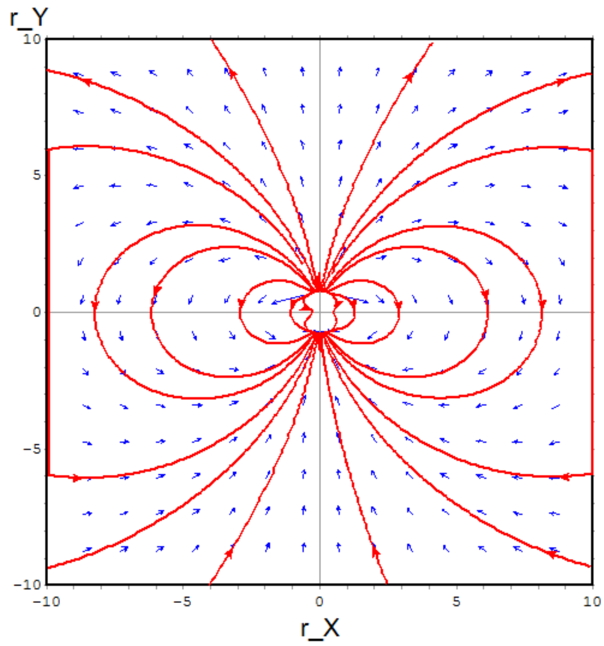

Figure 3: Dipole field with constant shivering terms.

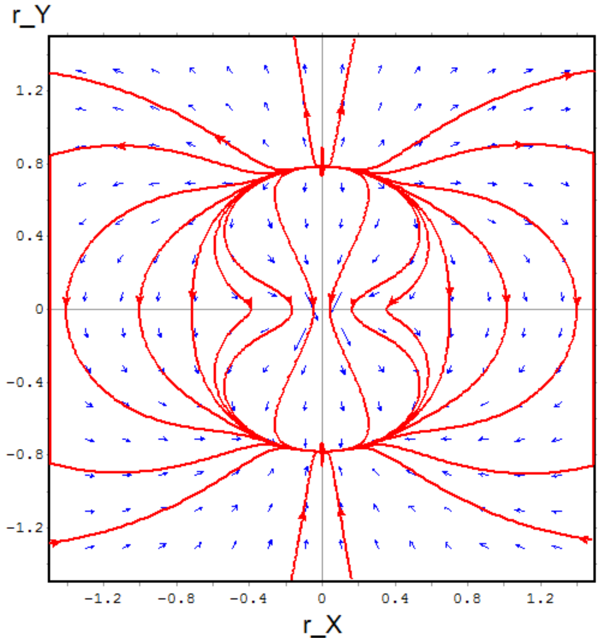

Figure 4: Magnified central region of the dipole field with constant shivering.

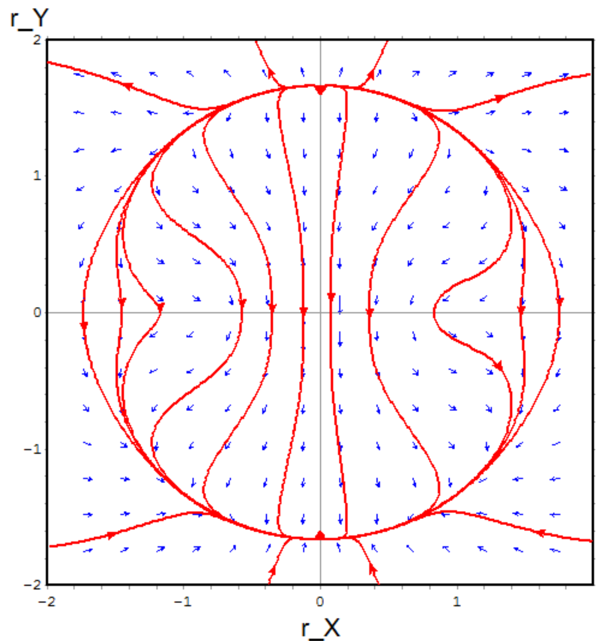

Figure 5: Dipole field with variable shivering radius, $\delta r \propto 1/r$.

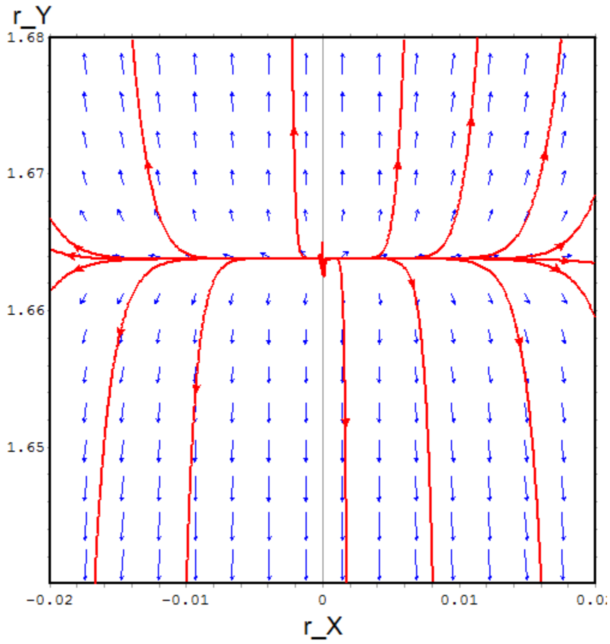

Figure 6: Magnified divergent region (upper) of Fig. 5.

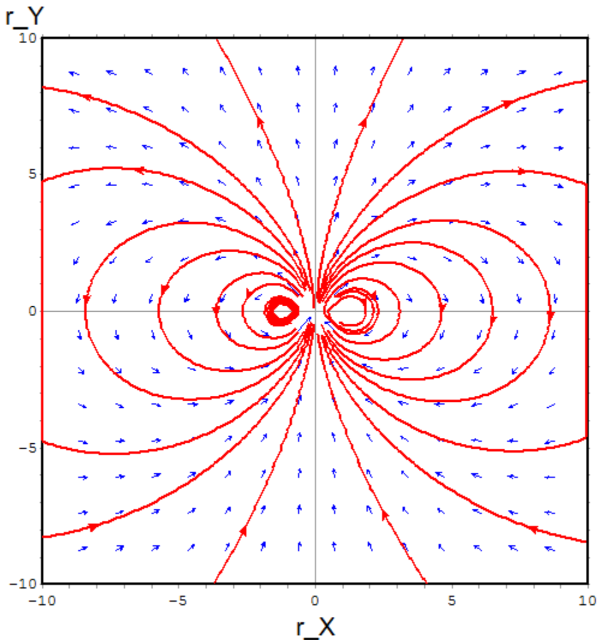

Figure 7: Dipole field with fourth order terms, variable shivering radius.

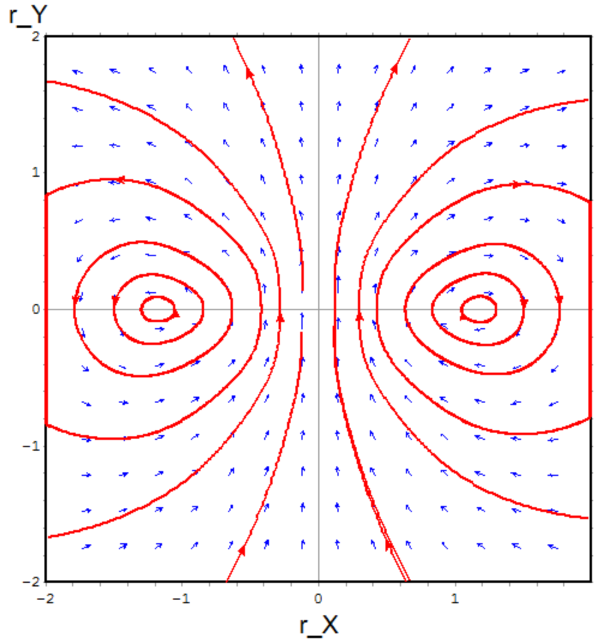

Figure 8: Magnified central structure of Fig. 7.

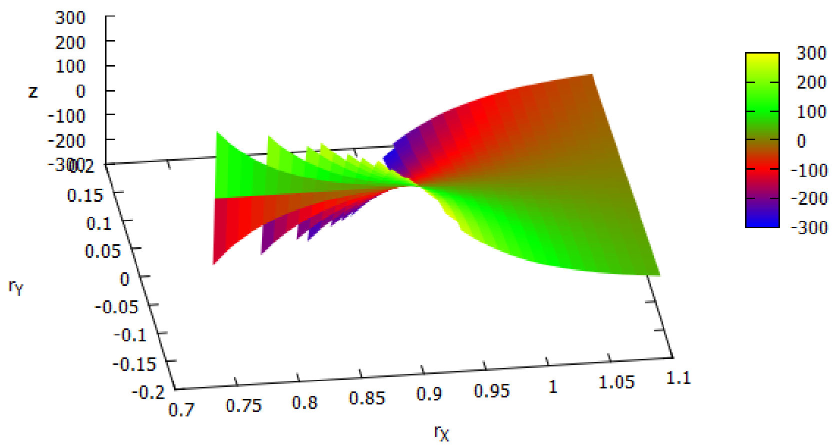

Figure 9: Divergence plot of Fig. 8 in the (r_X, r_Y) plane.

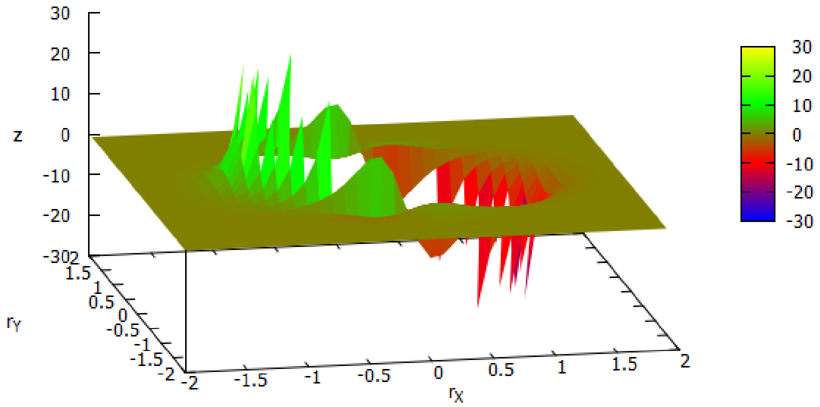

Figure 10: Curl **E** plot of Fig. 8 perpendicular to the (r_X, r_Y) plane.

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