ENERGY FROM SPACETIME IN FLUID ELECTRODYNAMICS

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ABSTRACT

A scheme of computation and animation is developed to calculate the electric field strength and magnetic flux density imparted to a circuit from the spacetime (or aether) of fluid electrodynamics. The scheme starts with the vorticity equation of fluid dynamics, in which the Reynolds number appears. All relevant quantities are computed in terms of the velocity field, which becomes turbulent at a given Reynolds number. A turbulent spacetime or aether can have measurable effects on the circuit in theory.

Keywords: ECE2, fluid electrodynamics, energy from spacetime.

UFT 352

1. INTRODUCTION

In recent papers of this series {1 - 12} the equations of fluid electrodynamics have been developed, based on Cartan geometry. The structures of the field equations of ECE2 electrodynamics and of fluid dynamics are the same, so concepts can be transferred from one area of physics to the other within the context of a geometrically based unified field theory (ECE2). In this paper a scheme of computation and animation is developed in order to show that in fluid electrodynamics, an electric field strength (E) and a magnetic flux density (B) can be imparted to a circuit from the velocity field v (r(t), t) of the ubiquitous spacetime (or aether) surrounding the circuit. The spacetime is considered to be a fluid with finite mass density and charge density. The spacetime fluid is governed by the equations of fluid dynamics, and is a source of charge density and current density in fluid electrodynamics.

This paper is a short synopsis of detailed calculations contained in the notes accompanying UFT352 on www.aias.us. Note 352(1) develops the vorticity equation of Kambe (UFT349 and UFT351) to include the Reynolds number. Notes 352(2) and 352(4) are simplifications of the Kambe vorticity equation. Note 353(3) considers the relevant time dependence of the field equations of Kambe in preparation for animation. Notes 352(5) to 352(7) develop the computation scheme which is the subject of this paper, and develop a method of computing E and B of the circuit from the velocity field of spacetime.

Section 2 is based on Notes 352(6) and 352(7) and express all relevant quantities in terms of the spacetime velocity field. The end result is a scheme for calculating E and B induced in the circuit by the velocity field of the spacetime or aether. Section 3 contains a description of computation, graphics and animation.

2. COMPUTATION / ANIMATION SCHEME

The first step is to calculate and animate the velocity field $\underline{v}(\underline{r}(t), t)$ of spacetime or the aether from the simplified vorticity equation developed in UFT349, UFT351 and notes for UFT352:

$$\frac{\partial \underline{v}}{\partial t} + \underline{w} \times \underline{v} = -\frac{1}{R} \underline{\nabla} \times \underline{w} . \quad -(1)$$

Here $\underline{w}$ is the vorticity:

$$\underline{w} = \underline{\nabla} \times \underline{v} . \quad -(2)$$

Subsequent steps calculate the Kambe charge of fluid dynamics from $\underline{v}$:

$$q_F = \underline{\nabla} \cdot \left((\underline{v} \cdot \underline{\nabla}) \underline{v} \right) \quad -(3)$$

and the Kambe current:

$$\underline{J}_F = \frac{\partial^2 \underline{v}}{\partial t^2} + \underline{\nabla} \left(\frac{\partial h}{\partial t} \right) + a_0^2 \, \underline{\nabla} \times \underline{w} \quad -(4)$$

in which h is the enthalpy per unit mass and a_0 is the assumed constant speed of sound.

The inhomogeneous Kambe field equations of fluid dynamics are:

$$\underline{\nabla} \cdot \underline{E}_F = q_F \quad -(5)$$

and

$$a_0^2 \, \underline{\nabla} \times \underline{w} - \frac{\partial \underline{E}_F}{\partial t} = \underline{J}_F \quad -(6)$$

and have the same structure as the inhomogeneous field equations of ECE2 electrodynamics (1 - 12}. The Kambe electric field is defined as:

$$\underline{E}_F = -\frac{\partial \underline{v}}{\partial t} - \underline{\nabla} h = (\underline{v}\cdot\underline{\nabla})\underline{v} \quad -(7)$$

so:

$$\underline{\nabla}\left(\frac{\partial h}{\partial t}\right) = \frac{\partial}{\partial t}\left(\underline{\nabla} h\right) = -\frac{\partial \underline{E}_F}{\partial t} - \frac{\partial^2 \underline{v}}{\partial t^2} \quad -(8)$$

and:

$$\underline{J}_F = -\frac{\partial \underline{E}_F}{\partial t} + a_0^2\, \underline{\nabla}\times(\underline{\nabla}\times\underline{v}). \quad -(9)$$

Therefore the Kambe current can be defined as:

$$\underline{J}_F = -\frac{\partial}{\partial t}\left((\underline{v}\cdot\underline{\nabla})\underline{v}\right) + a_0^2\, \underline{\nabla}\times(\underline{\nabla}\times\underline{v}) \quad -(10)$$

and calculated from $\underline{v}$.

The next step is to calculate the vacuum charge and current densities of fluid electrodynamics (UFT351):

$$\rho(\mathrm{vac}) = \frac{\epsilon_0 \rho_m}{\rho} q_F \quad -(11)$$

and

$$\underline{J}(\mathrm{vac}) = \frac{\epsilon_0 \rho_m}{\rho} \underline{J}_F \quad -(12)$$

where ρ_m is the mass density of the fluid electrodynamic spacetime and where ρ is the charge density. Here ϵ_0 is the S. I. permittivity in vacuo. Note that Eqs. (3) and (10) imply the continuity equation:

$$\frac{\partial q_F}{\partial t} + \underline{\nabla}\cdot\underline{J}_F = 0 \quad -(13)$$

because:

$$\underline{\nabla}\cdot\underline{\nabla}\times(\underline{\nabla}\times\underline{v}) = 0. \quad -(14)$$

The vacuum charge and current densities create $\underline{E}$ and $\underline{B}$ in a circuit through the Coulomb and Ampère Maxwell laws of fluid electrodynamics as follows:

$$\underline{\nabla}\cdot\left(\left(\frac{\rho}{\rho_m}\right)_{circuit}\underline{E}\right) = \frac{1}{\epsilon_0}\frac{\rho^2}{\rho_m}\,(\text{vacuum}) \quad -(15)$$

and

$$a_0^2\,\underline{\nabla}\times\left(\left(\frac{\rho}{\rho_m}\right)_{circuit}\underline{B}\right) - \frac{\partial}{\partial t}\left(\left(\frac{\rho}{\rho_m}\right)_{circuit}\underline{E}\right) = \frac{1}{\epsilon_0}\left(\frac{\rho}{\rho_m}\underline{J}\right)(\text{vacuum}) \quad -(16)$$

where $\left(\frac{\rho}{\rho_m}\right)_{circuit}$ denotes the ratio of ρ and ρ_m in the circuit.

It is also possible to develop a theory of energy from spacetime in fluid electrodynamics by considering firstly the wave equations of ECE2 electrodynamics, in which B and E are defined as:

$$\underline{B} = \underline{\nabla}\times\underline{W} \quad -(17)$$

and:

$$\underline{E} = -\frac{\partial\underline{W}}{\partial t} - \underline{\nabla}\phi_W. \quad -(18)$$

Using Eqs. (17) and (18) the homogeneous field equations of ECE2 become identities:

$$\underline{\nabla}\cdot\underline{B} = \underline{\nabla}\cdot\underline{\nabla}\times\underline{W} = 0 \quad -(19)$$

and:

$$\underline{\nabla}\times\underline{E} + \frac{\partial\underline{B}}{\partial t} = -\frac{\partial}{\partial t}(\underline{\nabla}\times\underline{W}) + \frac{\partial}{\partial t}(\underline{\nabla}\times\underline{W}) - \underline{\nabla}\times\underline{\nabla}\phi_W = 0. \quad -(20)$$

The inhomogeneous field equations of ECE2 are:

$$\underline{\nabla} \cdot \underline{E} = \rho / \epsilon_0 \quad -(21)$$

and:

$$\underline{\nabla} \times \underline{B} - \frac{1}{c^2} \frac{\partial \underline{E}}{\partial t} = \mu_0 \underline{J} \quad -(22)$$

where ρ is the electric charge density and $\underline{J}$ is the electric current density. Here μ_0 is the S. I. permeability in vacuo. The ECE2 Coulomb law (21) therefore transforms into:

$$\nabla^2 \phi_W + \frac{\partial}{\partial t}\left(\underline{\nabla} \cdot \underline{W}\right) = -\frac{\rho}{\epsilon_0} \quad -(23)$$

which is a second order wave equation in the potential ϕ_W, and the vector potential $\underline{W}$:

$$\nabla^2 \phi_W + \underline{\nabla} \cdot \frac{\partial \underline{W}}{\partial t} = -\frac{\rho}{\epsilon_0} . \quad -(24)$$

Eq (23) can be considered as the equation of a circuit in contact with the vacuum charge density . So:

$$\left(\nabla^2 \phi_W + \frac{\partial}{\partial t}\left(\underline{\nabla} \cdot \underline{W}\right)\right)_{circuit} = -\frac{1}{\epsilon_0} \rho(vac) \quad -(25)$$

where:

$$\rho(vac) = \epsilon_0 \left(\frac{\rho_m}{\rho}\right)_{vac} \nu_F . \quad -(26)$$

Here ρ_m is the mass density of the spacetime (or vacuum or aether) and ρ is the charge density of the spacetime.

The left hand side of Eq. (25) can be computed directly from Eqs. (3) and (26) given a parameterization of $(\rho_m / \rho)_{vac}$. Transition to turbulence in is governed by the Reynolds number R in Eq. (1).

Similarly the Ampere Maxwell law of ECE2 can be expressed as:

$$\underline{\nabla} \times (\underline{\nabla} \times \underline{W}) - \frac{1}{c^2}\frac{\partial}{\partial t}\left(-\frac{\partial \underline{W}}{\partial t} - \underline{\nabla}\phi_W\right)$$

$$= -\nabla^2 \underline{W} + \underline{\nabla}(\underline{\nabla} \cdot \underline{W}) + \frac{1}{c^2}\frac{\partial^2 \underline{W}}{\partial t^2} - \frac{1}{c^2}\underline{\nabla}\phi_W$$

$$= \mu_0 \underline{J} \quad -(27)$$

so:

$$\left(\frac{1}{c^2}\frac{\partial^2}{\partial t^2} - \nabla^2\right)\underline{W} + \underline{\nabla}(\underline{\nabla} \cdot \underline{W}) + \frac{1}{c^2}\frac{\partial}{\partial t}(\underline{\nabla}\phi_W) = \mu_0 \underline{J}. \quad -(28)$$

If the Lorenz gauge is assumed:

$$\partial_\mu W^\mu = \frac{1}{c^2}\frac{\partial \phi_W}{\partial t} + \underline{\nabla} \cdot \underline{W} = 0 \quad -(29)$$

Eq. (28) reduces to:

$$\square \underline{W} = \mu_0 \underline{J} \quad -(30)$$

where the d'Alembertian is defined by:

$$\square = \frac{1}{c^2}\frac{\partial^2}{\partial t^2} - \nabla^2. \quad -(31)$$

Using the condition (29) in Eq. (23) gives the result:

$$\square \phi_W = \rho / \epsilon_0 . \quad -(32)$$

In the above:

$$\partial_\mu = \left(\frac{1}{c}\frac{\partial}{\partial t}, \underline{\nabla}\right) \quad -(33)$$

and

$$W^\mu = \left(\frac{\phi_W}{c}, \underline{W}\right) \quad -(34)$$

Defining:

$$J^\mu = (c\rho, \underline{J}) \quad -(35)$$

it follows that:

$$\square W^\mu = \mu_0 J^\mu \quad -(36)$$

provided that:

$$\partial_\mu W^\mu = 0. \quad -(37)$$

Eq. (36) has the structure of the ECE wave equation {1 - 12}:

$$(\square + R)\, q^a_{\ \mu} = 0 \quad -(38)$$

where R is a well defined scalar curvature.

As described in detail in Notes 352(6) and 352(7), if the Lorenz gauge is not assumed then Eq. (36) becomes:

$$\square W^\mu + \mu_0 J^\mu(\text{circuit}) = \mu_0 J^\mu(\text{vacuum}) \quad -(39)$$

where:

$$\rho_{\text{circuit}} = -\epsilon_0 \left(\frac{1}{c^2} \frac{\partial^2 \phi_W}{\partial t^2} + \frac{\partial}{\partial t} \underline{\nabla} \cdot \underline{W} \right) \quad -(40)$$

and:

$$\underline{J}_{\text{circuit}} = \frac{1}{\mu_0} \left(\underline{\nabla} \left(\underline{\nabla} \cdot \underline{W} \right) + \frac{1}{c^2} \frac{\partial \phi_W}{\partial t} \right) \quad -(41)$$

and where:

$$J^\mu(\text{circuit}) = \left(c\rho(\text{circuit}), \underline{J}(\text{circuit}) \right)$$

Eq. (39) again has the structure of the ECE wave equation.

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3 Computation, graphics and animation

3.1 Equations inspected

Concerning the numerical solution of equations of fluid dynamics, one has to strictly discern between time-dependent and time-independent (stationary) flows. Time-dependent equations are numerically more stable and therefore easier to handle by finite-element solvers. As discussed in UFT Paper 351, all equations in this paper are homogeneous in the sense that there are no "sourceterms" indepenent of the flux velocity $\mathbf{v}$. This leads to a free floating solution which does not guarantee conservation of mass. Therefore a normalized scalar pressure field p has been added. The divergence of its gradient is assumed to be in proportion to the divergence of the velocity field:

$$\boldsymbol{\nabla} \cdot \boldsymbol{\nabla} p = P \, \boldsymbol{\nabla} \cdot \mathbf{v} \tag{43}$$

with a "penalty constant" P. Then the fundamental vorticity Equation (1) reads:

$$R \frac{\partial \mathbf{v}}{\partial t} + \boldsymbol{\nabla} \times \mathbf{w} + R \, \mathbf{w} \times \mathbf{v} + \boldsymbol{\nabla} p = \mathbf{0}. \tag{44}$$

The equation has been multiplied by R to allow for setting $R = 0$. For comparison we have studied the stationary form of this equation:

$$\boldsymbol{\nabla} \times \mathbf{w} + R \, \mathbf{w} \times \mathbf{v} + \boldsymbol{\nabla} p = \mathbf{0} \tag{45}$$

and another (a priori stationary) vorticity equation derived in note 352(2):

$$\boldsymbol{\nabla} \times \mathbf{w} - R \left(2 \, \mathbf{v} \times \mathbf{w} - \frac{1}{2} \boldsymbol{\nabla} v^2 \right) + \boldsymbol{\nabla} p = \mathbf{0}. \tag{46}$$

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3.2 Graphics and animation

The time evolution of Eq. (44) converges to a quasi-stationary state. Calculations have been carried out for different values of the Reynolds number R. The sample region is the same as for UFT paper 351. The velocity distribution in the plane $Y = 0$ has been graphed in Figs. 1-3 for parameters $R = 0.1$, 10 and 1000. The velocity maxima change from the output to the input and are distorted in the centre of inlet and outlet for the highest Reynolds number. The behaviour of turbulent structures is best studied by the vorticity $\mathbf{w}$. These are shown for the plane $Z = 0$ in Figs. 4-6 for the three Reynolds numbers. Obviously the structure becomes significantly more irregular for higher Reynolds numbers. It should be noted that the numerical precision is not optimal because of restrictions of the FEM program being available. Therefore results for high Reynolds numbers are not very reliable.

The time dependence of solutions has been processed to animations which will be published on the AIAS web site www.aias.us. The results are not always reproducible, they depend on the size of initial time integration steps. This is an indicator for a chaotic behaviour of solutions. Sometimes divergences appear in the main volume during the first steps of calculation. Then it takes longer to bring them to the inlet side which is the stationary final state. The calculations were always started with the valid solution $\mathbf{v} = \mathbf{0}$.

The other graphs show stationary solutions. The stationary form of Eq.(1), Eq. (45), can be solved for $R = 0$. This is not possible for the time-dependent equation. Comparing this solution (Fig. 7) with Fig. 1, it looks very similar, where the input velocity is even stronger reduced. This picture does not change significantly for Reynolds numbers up to 1000, showing that turbulence is mainly a dynamic effect. The same result was obtained from the equations solved in UFT paper 351.

The remaining graphs present results of Eq. (46), which is essentially an extension of Eq. (45) by a non-linear term. For $R = 0$, both equations give the same result. However, Eq. (46) gives converging solutions only for low Reynolds numbers. In Fig. 8 the velocity distribution for $R = 10$ is shown. In comparison with Fig. 2, the non-linear term leads to an enhancement of the input flow. The reason for this can be seen from Figs. 9 and 10, where the divergence of the velocity is graphed. In the main area of the plane the divergence vanishes, i.e. $\mathbf{v}$ is divergence-free there. Going from $R = 0$ to $R = 10$, the divergence region is relocated from the output to the input region. The vorticity (Figs. 11 and 12) shows a similar tendency, but less pronounced. The same holds for the current density $\mathbf{J}_F$ (Fig. 13-14, based on Eq. (10)).

3.3 Algorithms for deriving electromagnetic properties from flow properties

For future applications it is important to have a line of computing electromagnetic properties directly from the "aether flow field" $\mathbf{v}$. The following two procedures can be carried out. The first is:

1. solve the flow problem for $\mathbf{v}$
2. compute q_F by (3) and ρ_{vac} by (11)

3. compute electric potential ϕ_W by (25) assuming $\boldsymbol{\nabla} \times \mathbf{W} = 0$

4. compute electric field by $\mathbf{E} = -\boldsymbol{\nabla}\phi_W$ (eq. (18) without $\mathbf{W}$)

This seems particularly appropriate in case of electrostatic problems. If a magnetic field is required too, the second procedure is a bit more complicated:

1. compute $\mathbf{J}_F$ by (10) and $\mathbf{J}_{\text{vac}}$ by (12)

2. compute $\mathbf{W}$ by (30) where $\mathbf{J}_{\text{vac}}$ is used on the RHS

3. compute magnetic induction $\mathbf{B}$ by (17)

Alternatively, one could solve the Maxwell-Heaviside-like equations (20) and (22) directly with vacuum current on the right-hand side. Then the solution is fully time-dependent by definition and computation of potentials is avoided. Thus the aether problem is reduced to computing a (time-dependent) vacuum current density and all electrical properties will follow. Practical results will be given in later papers because volume definitions and boundary conditions for meaningful physical situations have to be developed first.

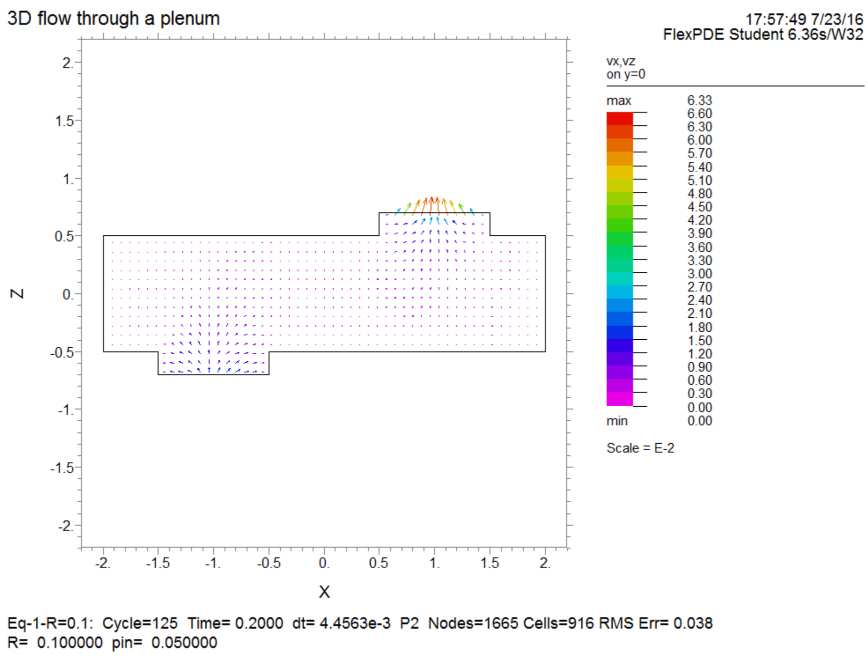

Figure 1: Velocity solution of Eq. (44) for $R = 0.1$.

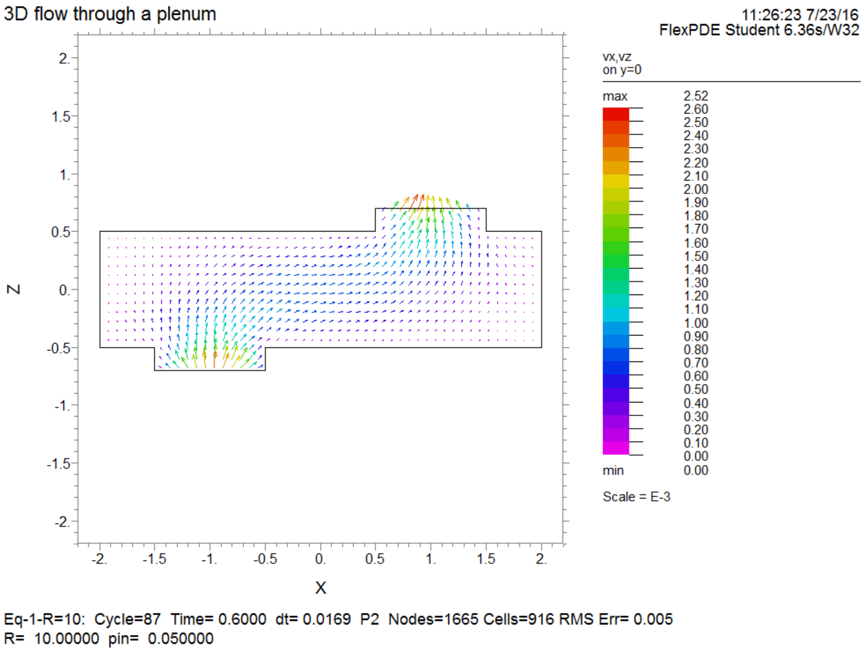

Figure 2: Velocity solution of Eq. (44) for $R = 10$.

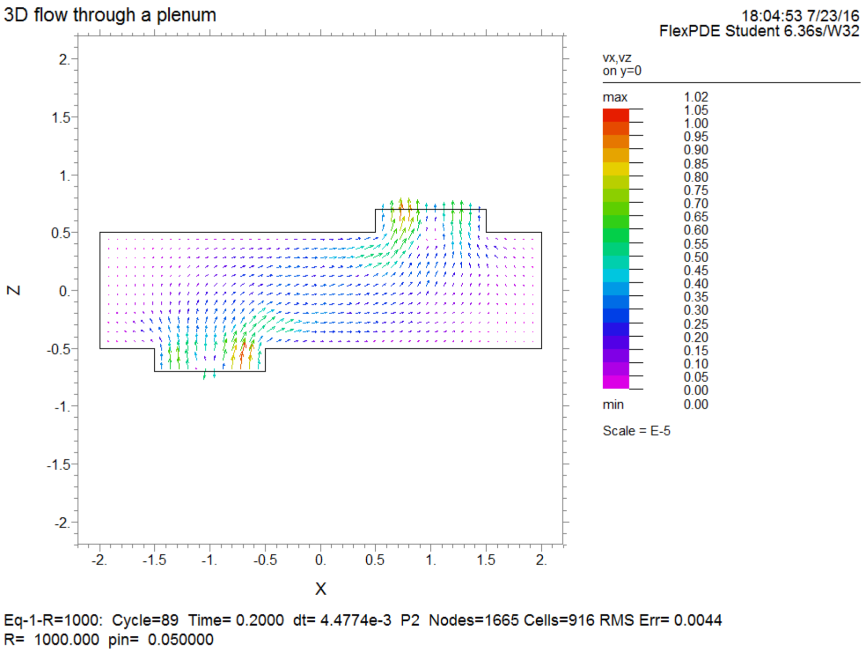

Figure 3: Velocity solution of Eq. (44) for $R = 1000$.

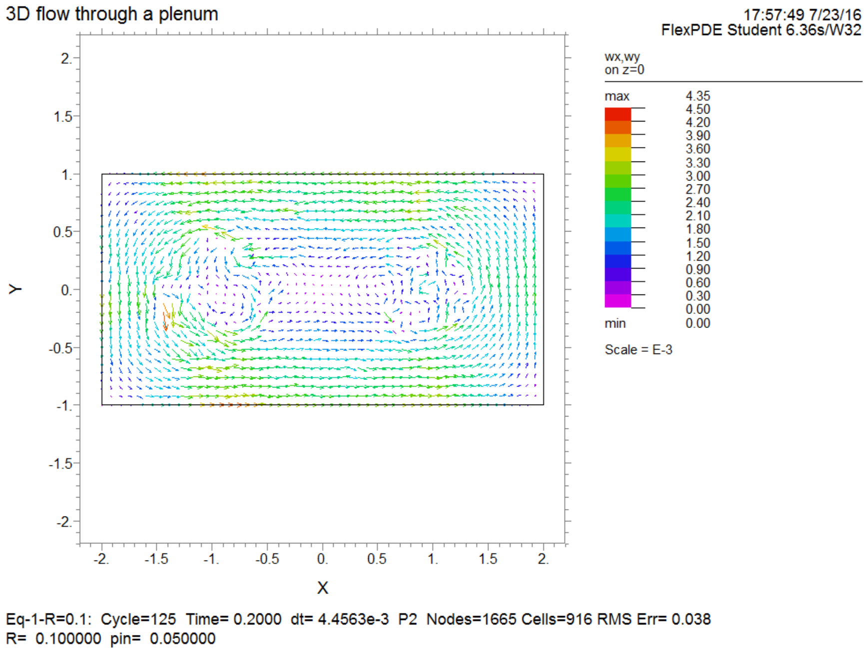

Figure 4: Vorticity from Eq. (44) for $R = 0.1$.

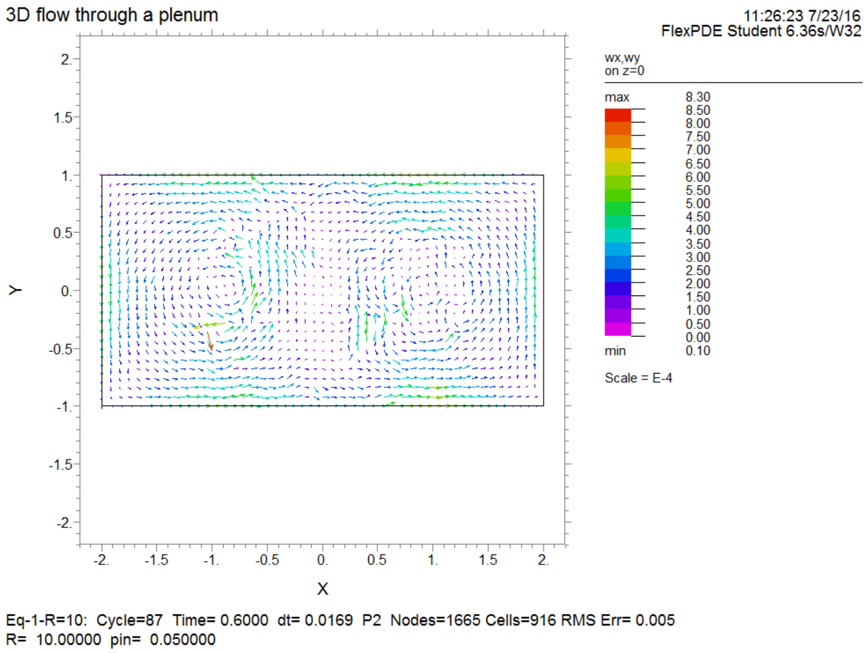

Figure 5: Vorticity from Eq. (44) for $R = 10$.

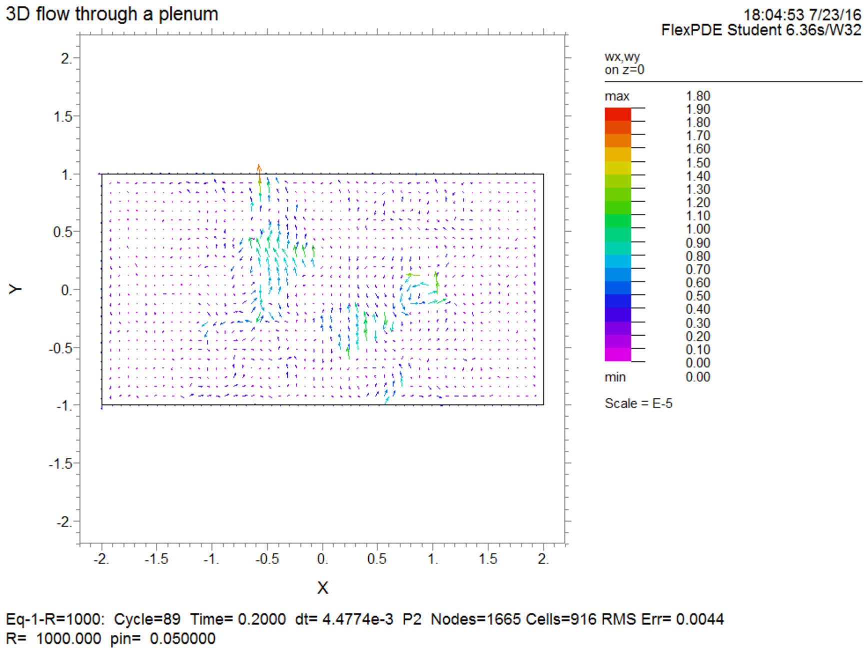

Figure 6: Vorticity from Eq. (44) for $R = 1000$.

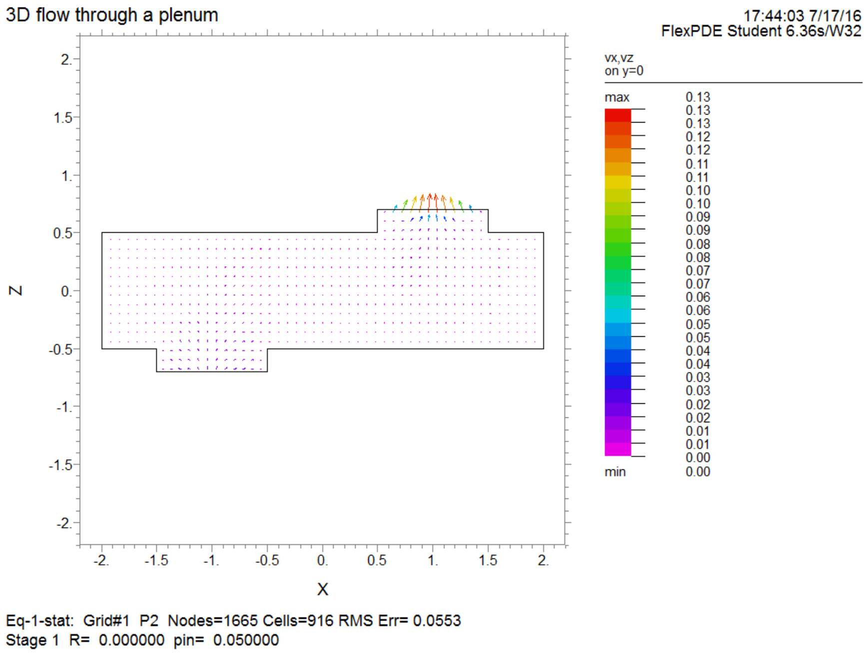

Figure 7: Velocity solution of static Eq. (45).

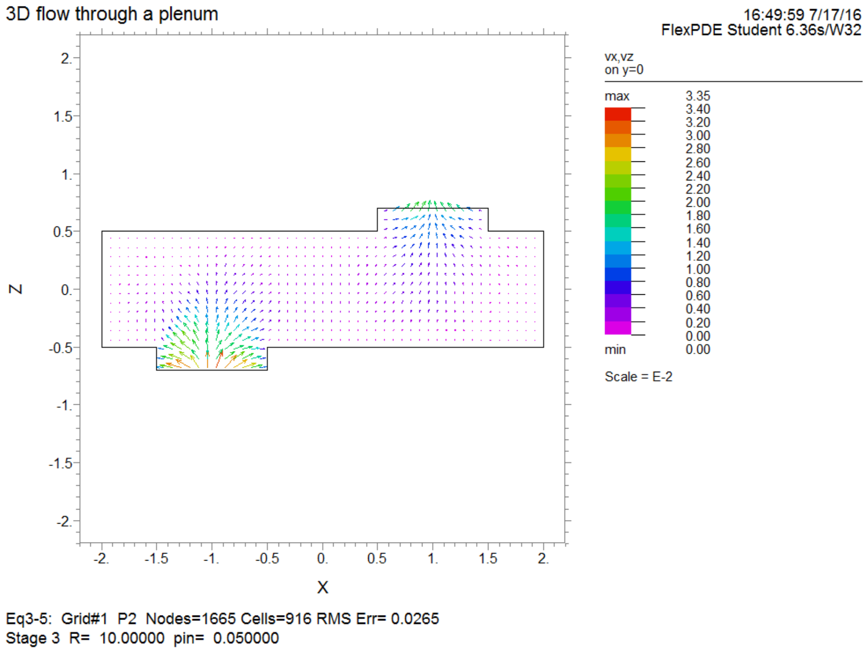

Figure 8: Velocity solution of (46) for $R = 10$.

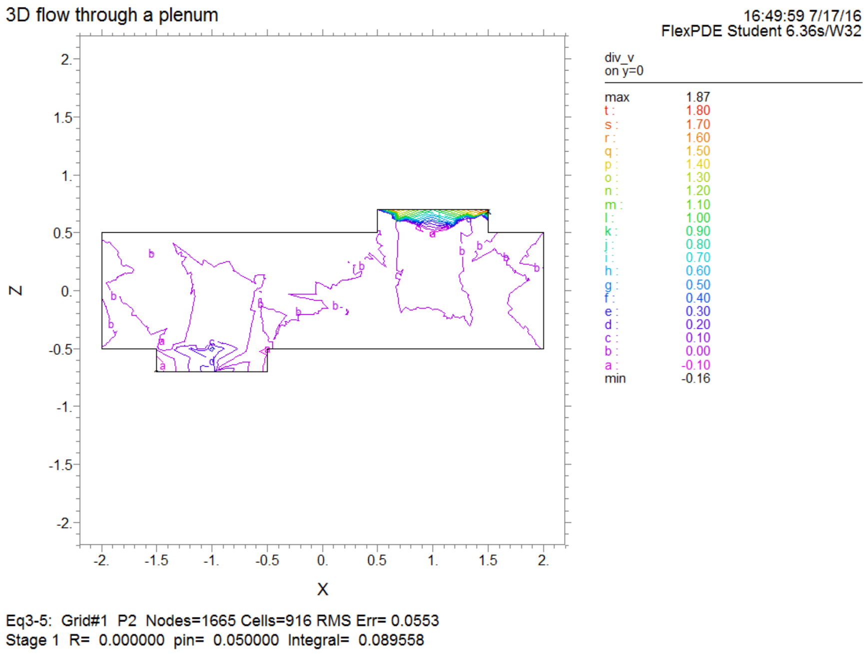

Figure 9: Divergence of velocity from Eq. (46) for $R = 0$.

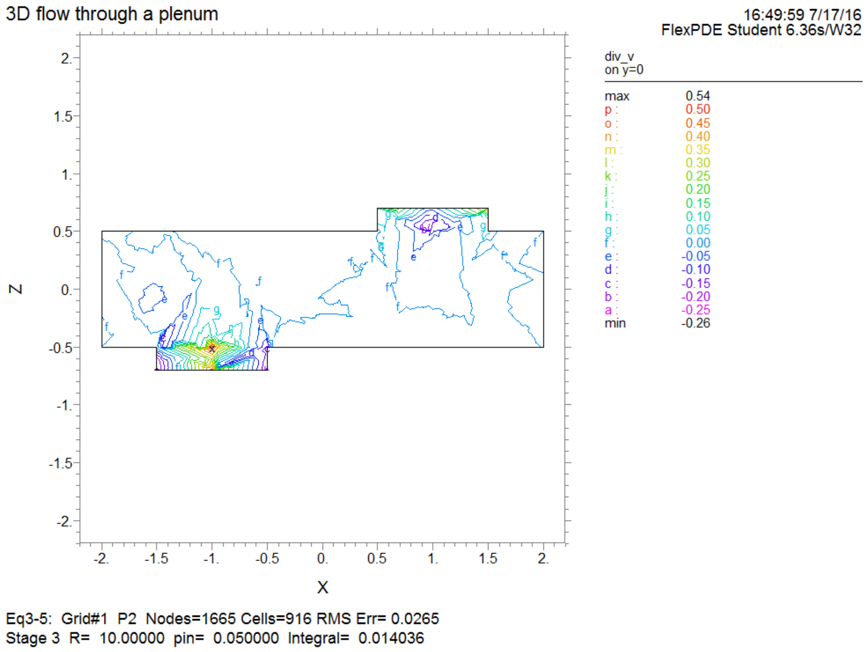

Figure 10: Divergence of velocity from Eq. (46) for $R = 10$.

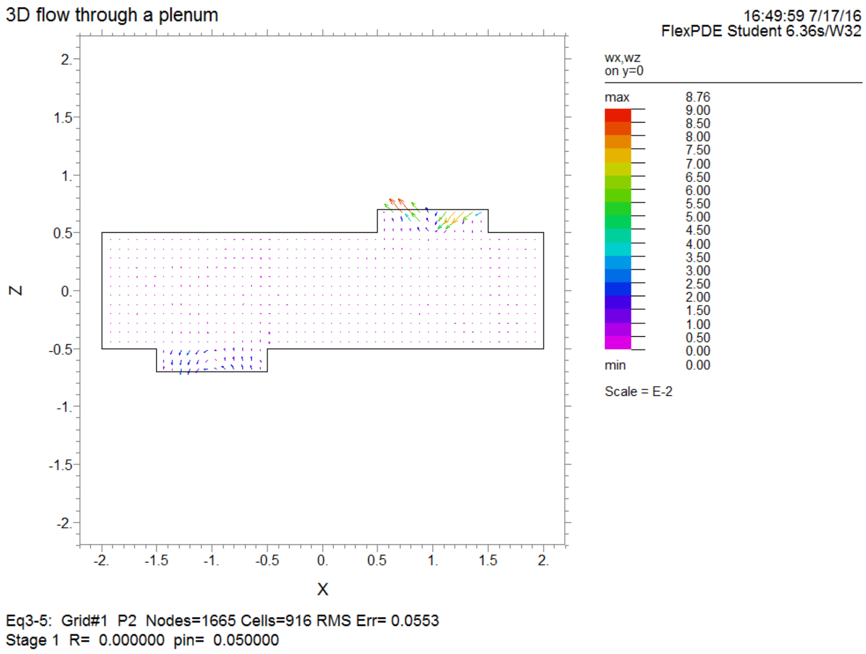

Figure 11: Vorticity from Eq. (46) for $R = 0$.

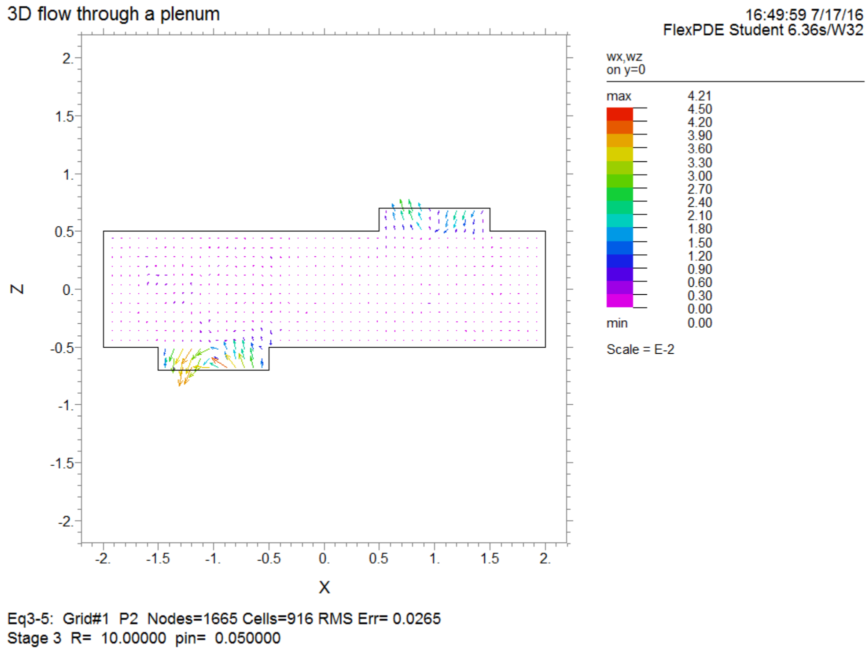

Figure 12: Vorticity from Eq. (46) for $R = 10$.

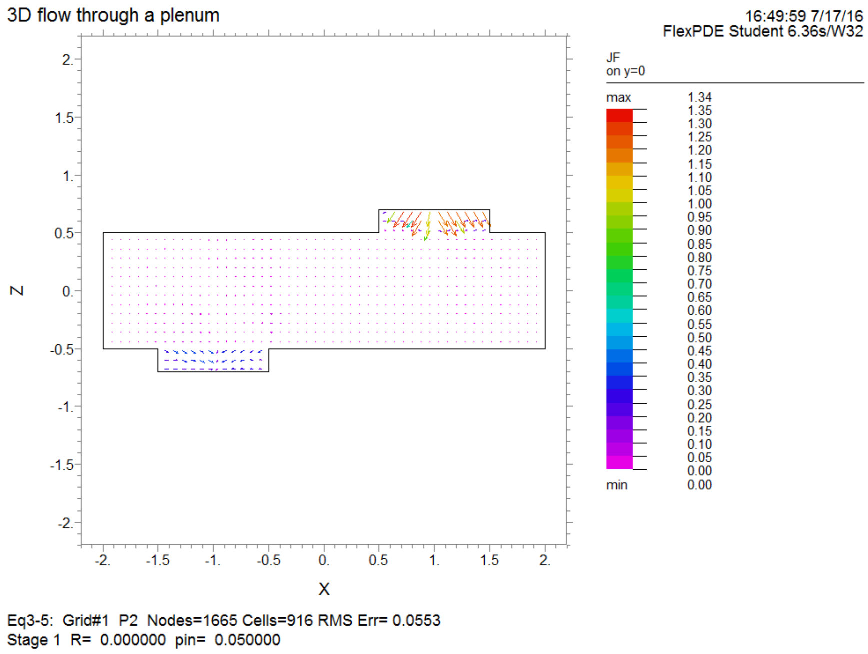

Figure 13: Current density $\mathbf{J}_F$ from Eq. (46) for $R = 0$.

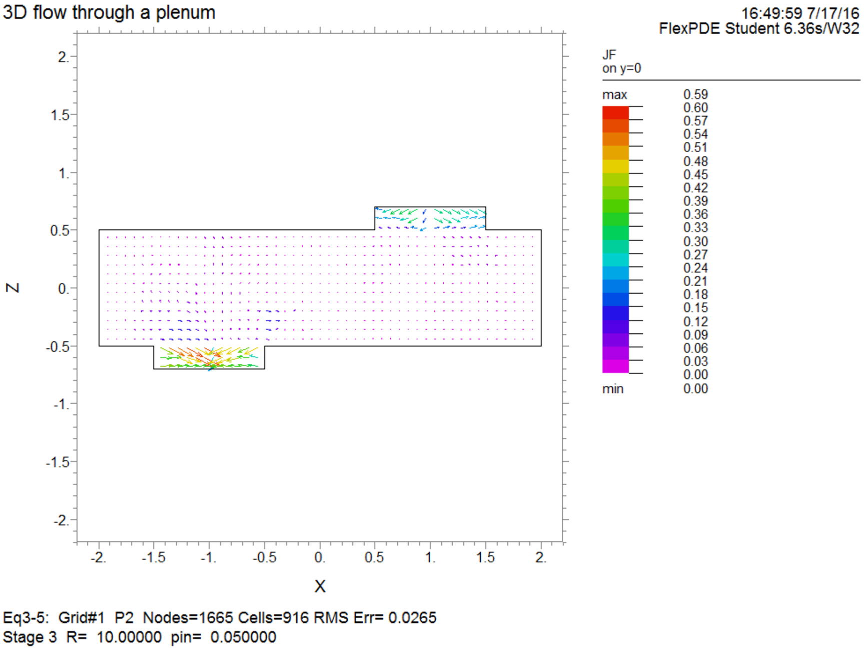

Figure 14: Current density $\mathbf{J}_F$ from Eq. (46) for $R = 10$.

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