

*Original Article*

# On Hypothesis of the Existence of Superfine Fluid that Producing Electromagnetic Field

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**Abstract:** Based on previous work of reformulation of equation for compressible fluid flow by analogy with Maxwell equation, further effort is successfully done to show similarity between governing equations for continuum, incompressible, non-viscous fluid flow and Maxwell equation for homogeneous medium without electric charge and without magnetic pole. From mathematical analysis of both system of equations, impulse vector in fluid field is equivalent with electric field in electromagnetic field, vorticity in fluid field is equivalent with magnetic fields in electromagnetic field, and speed of sound in fluid field is equivalent with speed of light in electromagnetic field. The success of finding the similarity leads to a hypothesis about the existence of a “superfine fluid” that forming background field in universe that having a characteristic similar with fluid field which is continuum, incompressible and inviscid.

**Keywords:** superfine fluid, compressible fluid flow, electromagnetic field, Maxwell equation

## 1. Introduction

Some effort to find similarity between governing equations of compressible fluid flow and Maxwell's equation has been done in reference [1]. Other efforts to reformulate fluid flow equations to relate some physical phenomena has been done in reference [2] and [3]. In this paper, a study to find similarity between governing equations of incompressible, non-viscous, continuum fluid flow and Maxwell's equation for a medium without charge and current has been carried out.

## 2. Materials and Methods

Maxwell's equations are a set of governing equations for electromagnetic field and table 1 shows the complete Maxwell's equation as appeared in [4]. While table 2 shows Maxwell's equation for medium without electric current and charge (homogeneous Maxwell's equation). Table 3 shows electromagnetic radiation equations for homogenous Maxwell's equations. In this study, we try to find a similarity between governing equation of electromagnetic field and fluid flow by reformulate governing equations of fluid flow to a form that similar with for electromagnetic field. Here,  $E$  is electric field,  $B$  is magnetic field,  $\rho$  is charge density,  $\epsilon$  is an electric permittivity,  $\mu$  is electric permeability, and  $J$  is current density.

**Table 1.** Complete Maxwell's equations.

|                            |                                                                                                     |
|----------------------------|-----------------------------------------------------------------------------------------------------|
| Gauss's law                | $\nabla \cdot \vec{E} = \frac{\rho}{\epsilon}$                                                      |
| Gauss's law for magnetism  | $\nabla \cdot \vec{B} = 0$                                                                          |
| Faraday's law of induction | $\nabla \times \vec{E} = -\frac{\partial \vec{B}}{\partial t}$                                      |
| Ampere's circuital law     | $\nabla \times \vec{B} = \mu \left( \vec{J} + \epsilon \frac{\partial \vec{E}}{\partial t} \right)$ |

**Table 2.** Homogeneous Maxwell's equation.

|                            |                                                                            |
|----------------------------|----------------------------------------------------------------------------|
| Gauss's law                | $\nabla \cdot \vec{E} = 0$                                                 |
| Gauss's law for magnetism  | $\nabla \cdot \vec{B} = 0$                                                 |
| Faraday's law of induction | $\nabla \times \vec{E} = -\frac{\partial \vec{B}}{\partial t}$             |
| Ampere's circuital law     | $\nabla \times \vec{B} = \mu \epsilon \frac{\partial \vec{E}}{\partial t}$ |

**Table 3.** Electromagnetic radiation.

|                      |                                                                                |
|----------------------|--------------------------------------------------------------------------------|
| For electric field   | $\nabla^2 \vec{E} - \frac{1}{c^2} \frac{\partial^2 \vec{E}}{\partial t^2} = 0$ |
| For magnetic field   | $\nabla^2 \vec{B} - \frac{1}{c^2} \frac{\partial^2 \vec{B}}{\partial t^2} = 0$ |
| Speed of propagation | $c^2 = \frac{1}{\mu \epsilon}$                                                 |

### 3. Results and Discussions

According to reference [5], Euler equation for inviscid flow in continuum fluid flow is as expressed in equation (1), where  $\vec{V}(x, y, z, t)$  is velocity of fluid element,  $p(x, y, z, t)$  is pressure of fluid element,  $\rho(x, y, z, t)$  is fluid density.

$$\rho \left[ \frac{\partial \vec{V}}{\partial t} + (\vec{V} \cdot \nabla) \vec{V} \right] = \rho \vec{g} - \nabla p \quad (1)$$

For purpose of this study, the Euler equation is simplified to be applied to incompressible flow where density,  $\rho(x, y, z, t)$  is a constant and there is no body force. So that equation (1) becomes

equation (2). And continuity equation for continuum, incompressible, and inviscid fluid flow is equation (3).

$$\frac{\partial \vec{V}}{\partial t} + (\vec{V} \cdot \nabla) \vec{V} = -\frac{\nabla p}{\rho} \quad (2)$$

$$\nabla \cdot \vec{V} = 0 \quad (3)$$

By doing divergence operation to equation (2), combine it with physical modelling of sound wave propagation as in equation (4) and (5) from reference [6], and by applying  $\nabla \rho = 0$ ,  $\nabla^2 p = 0$  for incompressible fluid flow, we get equation (6).

$$a^2 = \left( \frac{\partial p}{\partial \rho} \right)_s \quad (4)$$

$$\nabla p = a^2 \nabla \rho \quad (5)$$

$$\nabla \cdot [(\vec{V} \cdot \nabla) \vec{V}] = 0 \quad (6)$$

By applying curl operation to LHS and RHS of equation (2) and using vector identity  $\nabla \times \nabla p = 0$  that could be found in reference [7], we get equation (7).

$$\nabla \times [(\vec{V} \cdot \nabla) \vec{V}] = -\frac{\partial (\nabla \times \vec{V})}{\partial t} \quad (7)$$

Furthermore, by derivation partially both LHS and RHS of equation (2) with respect to time  $t$  we get equation (8). And then using chain rule to the second term of RHS in equation (8), using relation of equation (5) and divide both sides by  $a^2$ , we get equation (9).

$$\frac{\partial (\vec{V} \cdot \nabla) \vec{V}}{\partial t} = \frac{\partial^2 \vec{V}}{\partial t^2} + \nabla \left\{ \frac{\partial}{\partial t} \left( \frac{p}{\rho} \right) \right\} \quad (8)$$

$$-\frac{1}{a^2} \left( \frac{\partial (\vec{V} \cdot \nabla) \vec{V}}{\partial t} \right) = \frac{1}{a^2} \frac{\partial^2 \vec{V}}{\partial t^2} + \frac{1}{a^2} \left( \nabla \left\{ \left( \frac{a^2}{\rho} - \frac{p}{\rho^2} \right) \frac{\partial \rho}{\partial t} \right\} \right) \quad (9)$$

By using identity of vector operation of  $\nabla \times \nabla \times \vec{V} = \nabla(\nabla \cdot \vec{V}) - \nabla^2 \vec{V}$  that refer to reference [7] and by applying continuity equation (3), we get  $\nabla \times \nabla \times \vec{V} = -\nabla^2 \vec{V}$ . Adding this to equation (8), it becomes equation (10).

$$\nabla \times \nabla \times \vec{V} - \frac{1}{a^2} \left( \frac{\partial (\vec{V} \cdot \nabla) \vec{V}}{\partial t} \right) = \frac{1}{a^2} \left( \frac{\partial^2 \vec{V}}{\partial t^2} \right) - \nabla^2 \vec{V} + \frac{1}{a^2} \left( \nabla \left\{ \left( \frac{a^2}{\rho} - \frac{p}{\rho^2} \right) \frac{\partial \rho}{\partial t} \right\} \right) \quad (10)$$

We recognize that the two first terms of RHS of equation (10) is a wave equation that is equal to zero according to reference [8] and the last term of RHS of equation (10) is also zero because  $\rho$  is constant for incompressible flow. Then we arrive to equation (11).

$$\nabla \times \nabla \times \vec{V} = \frac{1}{a^2} \left( \frac{\partial (\vec{V} \cdot \nabla) \vec{V}}{\partial t} \right) \quad (11)$$

Now, let us introduce two well-known physical variables, which are vorticity of fluid,  $\omega^{\rightarrow} \equiv \nabla \times V^{\rightarrow}$ , and impulse or instantaneous momentum change that related to vorticity,  $\Omega^{\rightarrow} \equiv (V^{\rightarrow} \cdot \nabla)V^{\rightarrow}$ . Then, equation (6) becomes equation (12). Which means that  $\Omega^{\rightarrow}$  fulfils continuity of impulse flow  $\rho\Omega^{\rightarrow}$ . Furthermore, let us apply identity of  $\nabla \cdot (\nabla \times V^{\rightarrow}) = 0$  from other results [7] and the definition of vorticity to get equation (13). Equation (13) states that  $\omega^{\rightarrow}$  fulfils continuity of angular momentum  $\rho\omega^{\rightarrow}$ .

$$\nabla \cdot \vec{\Omega} = 0 \quad (12)$$

$$\nabla \cdot \vec{\omega} = 0 \quad (13)$$

Next, we substitute the definitions of  $\Omega^{\rightarrow}$  and  $\omega^{\rightarrow}$  to equation (7), we have equation (14). The same substitution is done to equation (11), and we have equation (15).

$$\nabla \times \vec{\Omega} = -\frac{\partial \vec{\omega}}{\partial t} \quad (14)$$

$$\nabla \times \vec{\omega} = \frac{1}{a^2} \left( \frac{\partial \vec{\Omega}}{\partial t} \right) \quad (15)$$

Moreover, applying curl operation to both LHS and RHS of equation (14) leads to equation (16). And substituting equation (15) to equation (16) and using vector operation identity of  $\nabla \times \nabla \times \Omega^{\rightarrow} = \nabla(\nabla \cdot \Omega^{\rightarrow}) - \nabla^2 \Omega^{\rightarrow}$  from reference [7,8], then using equation (12), we get equation (17).

$$\nabla \times \nabla \times \vec{\Omega} = -\frac{\partial (\nabla \times \vec{\omega})}{\partial t} \quad (16)$$

$$\nabla^2 \vec{\Omega} - \frac{1}{a^2} \frac{\partial^2 \vec{\Omega}}{\partial t^2} = 0 \quad (17)$$

To complete process of reformulate equation for fluid flow field, we do curl operation to LHS and RHS of equation (15) so we have equation (18). Then, by applying identity of vector operation as could refer to reference [7],  $\nabla \times \nabla \times \omega^{\rightarrow} = \nabla(\nabla \cdot \omega^{\rightarrow}) - \nabla^2 \omega^{\rightarrow}$ , and by using equation (12) and substituting equation (14), we arrive to equation (19).

$$\nabla \times \nabla \times \vec{\omega} = \frac{1}{a^2} \left( \frac{\partial (\nabla \times \vec{\Omega})}{\partial t} \right) \quad (18)$$

$$\nabla^2 \vec{\omega} - \frac{1}{a^2} \frac{\partial^2 \vec{\omega}}{\partial t^2} = 0 \quad (19)$$

From section 3 and section 4, we compare equations (12), (13), (14), and (15) with homogeneous Maxwell's equation in table 2, and we get table 4. Furthermore, comparing equations (16) and (19) with equations for electromagnetic radiation as appear in table 3, then we have table 5. We found a similarity between homogeneous Maxwell's equations for electromagnetic field and fluid flow field equations that has been reformulated in section (3).

The homogeneous Maxwell's equations here is for a medium with free electric charges and free electric current without magnetic monopole, while the reformulated fluid flow governing equations is for continuum, inviscid, incompressible flow [9,10].

**Table 4.** Similarity between homogeneous Maxwell's equation and reformulated flow field equations.

| Homogeneous Maxwell's equations                                             | Fluid field equations                                                                 | Equivalent variables                                                       |
|-----------------------------------------------------------------------------|---------------------------------------------------------------------------------------|----------------------------------------------------------------------------|
| $\nabla \cdot \vec{E} = 0$                                                  | $\nabla \cdot \vec{\Omega} = 0$                                                       | $\vec{\Omega} \cong \vec{E}$ (Impulse is equivalent with electric field)   |
| $\nabla \cdot \vec{B} = 0$                                                  | $\nabla \cdot \vec{\omega} = 0$                                                       | $\vec{\omega} \cong \vec{B}$ (Vorticity is equivalent with magnetic field) |
| $\nabla \times \vec{E} = -\frac{\partial \vec{B}}{\partial t}$              | $\nabla \times \vec{\Omega} = -\frac{\partial \vec{\omega}}{\partial t}$              |                                                                            |
| $\nabla \times \vec{B} = \frac{1}{c^2} \frac{\partial \vec{E}}{\partial t}$ | $\nabla \times \vec{\omega} = \frac{1}{a^2} \frac{\partial \vec{\Omega}}{\partial t}$ | $a \cong c$ (speed of sound is equivalent with speed of light)             |

**Table 5.** Similarity between form of wave equation in electromagnetic field and fluid field.

| Homogeneous Maxwell's equations                                                | Fluid field equations                                                                    | Equivalent variables                                                       |
|--------------------------------------------------------------------------------|------------------------------------------------------------------------------------------|----------------------------------------------------------------------------|
| $\nabla^2 \vec{E} - \frac{1}{c^2} \frac{\partial^2 \vec{E}}{\partial t^2} = 0$ | $\nabla^2 \vec{\Omega} - \frac{1}{a^2} \frac{\partial^2 \vec{\Omega}}{\partial t^2} = 0$ | $\vec{\Omega} \cong \vec{E}$ (Impulse is equivalent with electric field)   |
| $\nabla^2 \vec{B} - \frac{1}{c^2} \frac{\partial^2 \vec{B}}{\partial t^2} = 0$ | $\nabla^2 \vec{\omega} - \frac{1}{a^2} \frac{\partial^2 \vec{\omega}}{\partial t^2} = 0$ | $\vec{\omega} \cong \vec{B}$ (Vorticity is equivalent with magnetic field) |

## 5. Conclusions

In this study, it has been shown that if we reformulate Euler equation of fluid dynamics for inviscid, incompressible flow, we can form set of equations which like Maxwell's equation for medium that free charges and current and free magnetic monopoles (homogeneous Maxwell's equation). It is suspected that homogeneous Maxwell's equations could be traced to a background field that having similarity with hypothesized "superfine fluid" which is continuum, non-viscous, and incompressible. The idea of background radiation that might have connection with other previous founding. It is suspected that it may a superfine fluid in the universe that having low mass density but with high particle density so that it is continuum. To test the hypothesis by determining mass density of superfine fluid which is consistent with phenomena that appears in universe such as Mercury apsidal precession as in reference, that could be the further experiment in the space.

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