Towards an exact mechanical analogy of particles and fields (*)

V. P. DMITRIYEV (**)
Lomonosov University - Moscow, Russia

(ricavuto il 21 Aprile 1998; approvato il 13 Luglio 1998)

Summary. — An exact analogy of electromagnetic fields and particles can be found in continuum mechanics of a turbulent perfect fluid with voids. Deviations of the turbulence from a homogeneous isotropic state correspond to electromagnetic fields, with the average pressure as electrostatic potential, the average fluid velocity as magnetic vector potential and the density of the average turbulence energy as electromotive force. The waves of turbulence perturbation model the electromagnetic waves. Cavities of the fluid serve as walls to support stationary perturbations of turbulence. Cavitation of the turbulent noncorpuscular fluid occurring in the presence of voids leads to formation of dilatational inclusions of empty space and of the quiescent fluid. These model the positive and negative electrically charged particles, respectively. Due to the dilatation, the inclusions interact with the turbulence perturbation fields. This looks exactly as interaction of the charges with the electromagnetic fields. Splitting and dispersion of an inclusion in the stochastic environment model delocalization of a quantum particle.

PACS 12.60 - Models beyond the standard model.
PACS 47.27.Jv - High-Reynolds-number turbulence.
PACS 47.55.Bx - Cavitation.

1. - Introduction

We are in search of a mechanical medium capable to reproduce or imitate electromagnetism including charge and charged particles. Averaged turbulence in an inviscid incompressible fluid is considered. Following standard Reynolds scheme, an infinite chain of nonlinear equations for growing number of unknowns can be obtained. We choose among a variety of approximations the simplest one—minimal closure of the chain and linearizing the model. The consistent system of linear equations thus formed was found [1] to be isomorphic to the field part of Maxwell’s electromagnetic equations.

(*) The author of this paper has agreed to not receive the proofs for correction.
(**) E-mail: dmitr@cc.nifhi.ac.ru
The charge (and particle) portion of the theory will be shown below to be associated with voids in the fluid. The essential point is that the fluid is noncorpuscular. Hence, there is no entropy, no temperature and vapor phase cannot be existent. These give rise to a whole spectrum of structures which reproduce the world of particles as sources of stationary fields.

2. - Turbulence averaged

We describe the dynamics of a fluid in terms of the flow velocity \( \mathbf{u}(x, t) \) and the specific pressure \( p(x, t) \). Following the well-known in hydrodynamics Reynolds technique, we consider (short-time temporal or statistical) averages of the velocity and pressure, \( \langle \mathbf{u} \rangle \) and \( \langle p \rangle \), which are also functions of the space \( x \) and time \( t \) coordinates. Whence the turbulent pulsations \( u' \) and \( p' \) can be defined:

\[
(2.1) \quad u = \langle u \rangle + u', \quad p = \langle p \rangle + p'.
\]

The fluid is supposed to be incompressible, at least in its fluctuation component:

\[
\partial_t u' = 0.
\]

Putting (2.1) in Euler equation

\[
(2.2) \quad \partial_t u + u \partial_x u + \partial_j p = 0,
\]

averaging and taking account of \( \langle u' \rangle = 0, \langle p' \rangle = 0 \), we find for turbulence averages:

\[
(2.3) \quad \partial_t \langle u \rangle + \langle u \rangle \partial_x \langle u \rangle + \partial_j \langle u' u'_j \rangle + \partial_j \langle p \rangle = 0.
\]

Here and further on, \( \partial_j = \partial / \partial x_j \), \( \partial_x = \partial / \partial x_i \), \( i, k = 1, 2, 3 \) and summation over recurrent index is implied throughout.

In the ground state and also at infinity the turbulence is supposed to be homogeneous and isotropic:

\[
(2.4) \quad \langle u \rangle = 0, \quad \langle p \rangle = \text{const}, \quad \langle u' u'_i \rangle = c^2 \delta_{ik}.
\]

Integrating Reynolds equation (2.3) for the case of \( \langle u \rangle = \text{const} \), we may get

\[
(2.5) \quad \langle u' u'_i \rangle \delta_{ik} + \langle p \rangle = c^2 + \langle p \rangle.
\]

This is a kind of Bernoulli equation and actually an equation of state of ideal isotropic turbulence. It implies rather a broad range of variation for the turbulence energy density \( 1/2 \langle u' u' \rangle \) and pressure, involving coexistence of different turbulence phases.

3. - Perturbations of turbulence

Equation (3.3) represents the first link in the chain of dynamical equations for consecutive moments of turbulent pulsations. Next equation is received multiplying (3.2) by \( u' \), symmetrizing, substituting in it (3.1) and averaging:

\[
(3.1) \quad \langle u'_i [\partial_j (\langle u_j \rangle + u'_j) + u'_i] + \langle u'_j \rangle \partial_i (\langle u_i \rangle + u'_i) + \partial_i (\langle p \rangle + p') + u'_i [\partial_i (\langle u^j \rangle + u'_{ik}) + \langle u^j \rangle \partial_i (\langle u^j \rangle + u'_{ik}) + \partial_k (\langle p \rangle + p')] \rangle = 0.
\]