Quantum Theory of Fields from Planck to Cosmic Scales

SIAVASH H. SOHRAB
Robert McCormick School of Engineering and Applied Science
Department of Mechanical Engineering
Northwestern University, Evanston, Illinois 60208
s-sohrab@northwestern.edu
http://www.mech.northwestern.edu/web/people/faculty/sohrab.php

Abstract: - A scale invariant model of statistical mechanics is applied to describe a modified statistical theory of turbulence and its quantum mechanical foundations. Hierarchies of statistical fields from cosmic to *Planck* scales are described. Energy spectrum of equilibrium isotropic turbulence is shown to follow *Planck* law. Predicted velocity profiles of turbulent boundary layer over a flat plate at four consecutive scales of LED, LCD, LMD, and LAD are shown to be in close agreement with the experimental observations in the literature. The physical and quantum nature of time is described and a scale-invariant definition of time is presented and its relativistic behavior is examined. New paradigms for physical foundations of quantum mechanics as well as derivation of *Dirac* relativistic wave equation are introduced.

Key-Words: - Theory of turbulence; Quantum mechanics; Relativity; Dirac and Schrödinger equations; TOE.

1 Introduction

It is well known that the laws of nature appear to reveal ever increasing similarities over a broad range of scales of space and time from the exceedingly large scale of cosmology to the minute scale of quantum optics (Fig.1). The similarities between stochastic quantum fields [1-17] and classical hydrodynamic fields [18-29] resulted in recent introduction of a scale-invariant model of statistical mechanics [30], and its application to thermodynamics [31] and fluid mechanics [32].

More recently, the implication of the model to the statistical theory of turbulence [33, 34] was investigated. In the present study the physical foundations of the problems of turbulence and quantum mechanics are further examined. Homogenous isotropic turbulence is identified as a spectrum of eddies (energy levels) with *Gaussian* velocity distribution, *Planck* energy distribution, and *Maxwell-Boltzmann* speed distribution. The nature of dissipation spectrum of isotropic turbulence is examined and a derivation of *Dirac* relativistic wave equation is presented.

2 A Scale Invariant Model of Statistical Mechanics

Following the classical methods [35-39] the invariant definitions of density ρ_β, and velocity of *atom* $\mathbf{u}_\beta$, *element* $\mathbf{v}_\beta$, and *system* $\mathbf{w}_\beta$ at the scale β are given as [31]

$$\rho_\beta = n_\beta m_\beta = m_\beta \int f_\beta du_\beta \quad , \quad \mathbf{u}_\beta = \mathbf{v}_{\beta-1} \tag{1}$$

$$\mathbf{v}_\beta = \rho_\beta^{-1} m_\beta \int \mathbf{u}_\beta f_\beta d\mathbf{u}_\beta \quad , \quad \mathbf{w}_\beta = \mathbf{v}_{\beta+1} \tag{2}$$

Similarly, the invariant definition of the peculiar and diffusion velocities are introduced as

$$\mathbf{V}'_\beta = \mathbf{u}_\beta - \mathbf{v}_\beta \quad , \quad \mathbf{V}_\beta = \mathbf{v}_\beta - \mathbf{w}_\beta \tag{3}$$

such that

$$\mathbf{V}_\beta = \mathbf{V}'_{\beta+1} \tag{4}$$

For each statistical field, one defines particles that form the background fluid and are viewed as point-mass or "*atom*" of the field. Next, the *elements* of the field are defined as finite-sized composite entities each composed of an ensemble of "*atoms*" as shown in Fig.1.

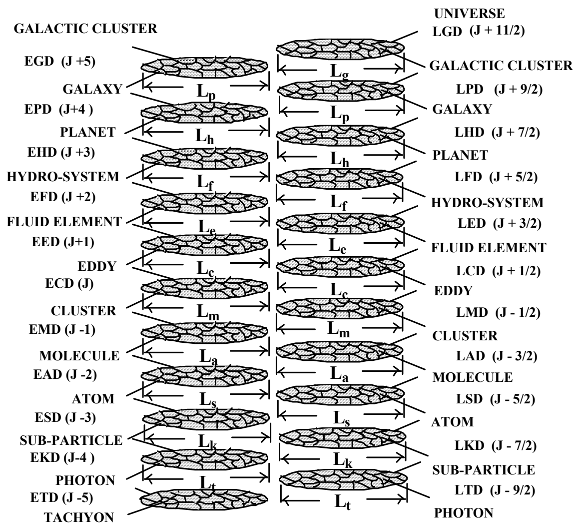

Fig.1 A scale invariant view of statistical mechanics from cosmic to tachyon scales.