Thermo-statistical analogues of Hamilton-Jacobi and Einstein field equations

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Abstract

Riemannian formulation of classical fluctuation theory [1] appears after imposing the principle of general covariance, which requires a reformulation of Einstein postulate of classical fluctuation theory and Ruppeiner geometry of thermodynamics. This proposal predicts thermo-statistical counterparts of Hamilton-Jacobi equation of classical mechanics:

$$-\frac{\partial}{\partial\tau}\mathcal{S}(x,\tau)=\frac{1}{2}w\left[-g^{ij}(x)\frac{\partial\mathcal{S}(x,\tau)}{\partial x^{i}}\frac{\partial\mathcal{S}(x,\tau)}{\partial x^{j}}+\ell^{2}(x|\bar{x})\right]. \tag{1}$$

and Einstein field equations of general relativity:

$$R_{ij}-\frac{1}{2}g_{ij}R-\frac{1}{2\kappa}(d-2)g_{ij}=T_{ij}. \tag{2}$$

The first analogy leads to a Riemannian extension of Onsager-Machlup theory of non-equilibrium thermodynamics, whose mathematical apparatuses resemble the ones of classical and quantum mechanics. The second analogy suggests that general relativity is the deterministic limit of a certain *information geometry* defined on the spacetime. This viewpoint is highly motivated by the interpretation of *time measuring* as a process of *statistical inference*. The existing analogies between microphysics and macrophysics [2] are analyzed within recently proposed *complex time approach* [3] (micro-macro coexistence scenario). This analysis motivates the introduction of the local Lorentzian metric for the complex 5D spacetime $\mathbb{M}^{5}\simeq\mathbb{C}\otimes\mathbb{R}^{3}$:

$$d\ell^{2}=\varepsilon_{P}^{2}\left[|dz|^{2}-\left(\frac{1}{\hbar c}d\mathbf{x}\right)^{2}\right]=\frac{\hbar c^{5}}{G}\left[\frac{1}{4\kappa^{2}}d\eta^{2}+\frac{1}{\hbar^{2}}\left(dt^{2}-\frac{1}{c^{2}}d\mathbf{x}^{2}\right)\right], \tag{3}$$

which favors a *gravitational origin* of the observed *macroscopic irreversibility* instead of a *thermodynamic emergence of gravitation* [4]. Apparently, this connection seems to be closely related with other two (unsolved) fundamental problem of physics.

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