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Generalization of framework of analytic mechanics and unified description of quantum and classical physics

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Variational principle plays a fundamental role in elucidating the structure of classical mechanics, clarifying the origin of dynamics and the relation between symmetries and conservation laws. In classical mechanics, the optimized function is characterized by Lagrangian, defined as T-V with T and V being a kinetic and a potential terms, respectively. We can still argue a variational principle even in quantum mechanics, but the Lagrangian does not have the form of T-V any more. Therefore, at first glance, any clear or direct correspondence between classical and quantum mechanics does not seem to exist from the variational point of view, but it does exist. For this, we need to extend the usual variational method to the case of stochastic variables. This is called stochastic variational method (SVM). The Schrödinger equation can be then obtained by the stochastic optimization of the action which leads to, meanwhile, the Newton equation in the application of the classical variation. From this point of view, quantization can be regarded as a process of stochastic optimization and the invariance of the action leads to the conservation laws in quantum mechanics. In this manner, classical and quantum behaviors are described in a unified way under SVM. Although SVM was originally proposed as the reformulation of Nelson's stochastic quantization, its applicability is not restricted to quantization. In fact, dissipative dynamics such as the Navier-Stokes-Fourier (viscous fluid) equation can be obtained by applying SVM to the Lagrangian which leads to the Euler (ideal fluid) equation in the classical variational method. This method is useful even to obtain coarse-grained dynamics. For example, the Gross-Pitaevskii equation is regarded as an optimized dynamics in SVM. Therefore it is possible to consider that the study of SVM enables us to generalize the framework of analytic mechanics.

Biography

Tomoi Koide is a Professor at Institute of Physics, Federal University of Rio de Janeiro, Brazil. He has completed his PhD from Tohoku University, Japan and Post-doctoral studies from Frankfurt University, Federal University of Rio de Janeiro and so on. He has published more than 60 papers in reputed journals.

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