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Habilitation Thesis Reviewer's Report

Masaryk University Faculty	FACULTY OF SCIENCE
Procedure field	THEORETICAL PHYSICS AND ASTROPHYSICS
Applicant	Dr. Klaus Bering Larsen
Applicant's home unit, institution	MASARYK UNIVERSITY
Habilitation thesis	Odd Scalar Curvature in Batalin-Vilkovisky Geometry
Reviewer	Dr. Maxim Grigoriev
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The habilitation thesis of Klaus Bering is devoted to the geometry of Batalin-Vilkovisky (BV) formalism. This approach was originally developed as a tool to quantize gauge theories. It allows to systematically construct a nondegenerate action functional suitable for path-integration by extending the initial action to depend on new field variables known as ghosts and antifields followed by restricting the BV-action to a gauge-fixing submanifold. The quantization prescription is gauge-independent in the sense that the path-integral does not change under the infinitesimal variation of the gauge fixing submanifold.

The use of BV formalism is by far not limited to the original applications in gauge theories quantization. It was soon realized that it gives a proper language to handle gauge theories. In particular, it was successfully applied in renormalization of gauge theories. Moreover, BV approach can be considered as a mean to construct new gauge theories. For instance, Barnich and Henneaux showed that the problem of finding consistent interactions for a given linear theory can be cast into a usual deformation theory framework by reformulating the probelm in terms of BV formalism. In so doing the consistent interactions are controlled by local BV-BRST cohomology, giving a well defined mathematical framework for studying interactions and deformations. Furthermore, Bochicchio and, independently, Thorn demonstrated that String Field Theory can be built in the BV-formalism terms from the very beginning starting from the BRST first-quantized string. Somewhat similar is the approach of Alexandrov, Kontsevich, Schwartz, and Zaboronsky in which BV formulation of interesting topological theories is constructed in terms of finite-dimensional Q-manifold equipped with a compatible odd symplectic structure.

The heart of BV formalism is the so called Δ-operator which encodes both the odd Poison structure and the volume form and controls the gauge-independence of the path integral. Despite its importance for quantization Δ-operator and its possible generalizations are not sufficiently understood. That Δ-operator is a deep geometrical object was understood already by Schwartz. An interesting interpretation of the underlying geometry was proposed by

Khudaverdian who observed that Δ-operator can be naturally defined on semi-densities without the need to specify a volume form. This has also deep physical interpretation as Δ-operator can be thought of as a quantum operator defined on wave functions which have natural geometric interpretation of semi-densities defined on the configuration space. Despite there should be a deep geometrical principle underlying this observation the definition of Δ-operator in general coordinates was not known while the existing definition explicitly employed Darboux coordinates.

The habiltation thesis of Klaus Bering comprises his results on BV geometry and the structure and possible generalizations of Δ-operator. Among these results the important contribution to the subject is the explicit formula for Δ-operator on semi-densities in terms of general local coordinate system. Not only this has solved an intriguing problem of missing covariant expression for the Δ-operator but also uncovered certain hidden structures. In particular, given a volume form such Δ-operator determines a scalar odd function called later the odd scalar. Klaus has shown (in collaboration with I.Batalin) that this function can be identified with the odd curvature of a compatible torsion-free connection and moreover does not depend on the choice of the connection. These results were also generalized to the case of regular but not necessarily nondegenerate odd Poisson structures.

These and other results of Bering are well known in the community. He is considered as a well-known expert in the BV quantization, its generalizations, and underlying geometry. Well known in the community are also his earlier results on super-field and non-commutative generalizations of the BV approach. The thesis is based on at least 5 papers published in the leading mathematical physics journals.

Conclusion

The habilitation thesis entitled "Odd Scalar Curvature in Batalin-Vilkovisky Geometry" by Klaus Bering Larsen fulfils all the requirements expected of a habilitation thesis in the field of theoretical physics and astrophysics.

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