physics

Editorial

New Advances in Quantum Geometry

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1. Introduction

Presently, we are in a period of rapid and intensive changes in our understanding of the gravitational interaction, triggered by the important observational findings of the late 1990s. We have witnessed the emergence of new cosmological paradigms and a better understanding of black hole properties, as well as a tremendous increase in the precision of observational data. However, in the understanding of one of the most fundamental questions of present day physics, the nature of quantum gravity, many unsolved questions still remain. Can gravity be quantized at all? Is the gravitational force a purely geometric effect, or is it field theoretic in nature? And, if gravity is pure geometry, what is the relation between geometry and the quantum? Is it possible to quantize geometry, to create a unified quantum geometric framework for gravity?

2. Scope and Aims of the Project

This Special Issue is focused on the fundamental question of quantum geometry, its various meanings, and its implications for the standard theoretical concepts in gravitation and cosmology. The Issue includes state-of-the-art research contributions in the following areas: the quantum geometry created by quantum matter [1], quantum metric fluctuations [2], cosmology in modified gravity models [3,4], de Sitter gauge theory [5], and matrix theory models of the gravitational interaction [6]. The nature of quantum configurations in phase space [7], momentum operators in intrinsically curved manifolds [8], uncertainty relations in the presence of a minimal length [9], generalized uncertainty black holes [10], and the effects of quantum gravity on mass scales at high energies [11] are also addressed. These fascinating topics, in which geometry, gravity and quantum mechanics are brought together, provide deeper insights into the unsolved mysteries of the gravitational interaction, at the smallest possible scales.

Review papers also play an essential role, both in synthesizing the available knowledge in a given field of science and in providing the key information required to understand the most advanced topics in contemporary research. Two reviews, one on noncommutativity in physics [12] and another on the Barbero–Immirzi parameter in loop quantum gravity [13], provide good introductions to these subjects, and overviews of some important recent results in these fascinating fields of basic research.

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As the Guest Editors of this Special Issue, we hope that this collection will serve as a standard reference for initiating and continuing state-of-the-art research in the fundamental fields of quantum geometry, quantum gravity, and geometric theories of gravitation. Moreover, we hope that the Issue opens up some new perspectives on the quantum-geometric aspects of the gravitational field and its applications in astrophysics and cosmology. Our sincere thanks to all the authors who contributed to this volume, and without whom it would not have been possible, for their time and efforts.

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