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*Editorial*

# Editorial for the Special Issue "Torsion-Gravity and Spinors in Fundamental Theoretical Physics"

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The Einsteinian theory of gravitation is among the best-established theories ever conceived in physics. Based on the geometrical idea that the energy density of matter could curve space-time, Einstein's field equations embrace conceptual simplicity, mathematical elegance and predictive power like few others.

One of the few cases of synthesis between simplicity, elegance and power is Maxwell's equations in electrodynamics, and they, too, are based on a similar geometrical idea, that the current density of matter curves the gauge potential. The electromagnetic tensor $F_{\mu\nu}$ in fact can be seen as the curvature of the gauge bundle in the same way in which the Riemann tensor $R_{\alpha\rho\mu\nu}$ is the curvature of the frame bundle.

However, now, the quick student or the attentive reader would raise the following question: given that the material Lagrangian generates energy, current and spin densities then, in the same spirit followed above, what does the spin density curve? The answer is that, hidden in the deep recesses of differential geometry, if care is taken to look attentively, there actually is an object whose curvature can be tied to the spin density: torsion.

Torsion, the antisymmetric part (in holonomic coordinates) of the most general connection, is a natural attribute of the geometric background in which Einsteinian gravity is built. With it, the torsional completion of Einsteinian gravity is the theory in which the space-time curvature couples to energy in the same manner in which the space-time torsion couples to spin, and in the same manner in which the gauge strength couples to the current.

Because the matter field that has both energy and spin, as well as current, is the spin fluid or the spinor field, use of the Weyssenhoff or Dirac theories becomes essential. As a consequence, the torsion field is expected to acquire a considerable prominence whenever spin effects might be important.

Of course this brings us, first of all, to quantum mechanics. But it may also bring us, perhaps not surprisingly, to the cosmology of black holes or of the early Universe, or in all those situations where the spin density is dominant.

The present collection brings together various experts in the field to make the present status of torsion in gravity and spin in quantum field theory a little clearer.

There are ten papers in this collection, split into two sections: The first is the review section and consists of three papers. The first, and largest of all, is Fundamental Theory of Torsion Gravity [1], written by myself with the aim of providing a basic reference for all following papers, as well as some historical introductions that readers might find interesting. The other two papers are Some Mathematical Aspects of $f(R)$-Gravity with Torsion: Cauchy Problem and Junction Conditions [2] by S. Vignolo and On the Mathematics of Coframe Formalism and Einstein-Cartan Theory–A Brief Review [3] by M. Tecchiolli, complementing the introduction with mathematical details on the structure of the differential equations of the theory and the presentation of the tetradic formulation.

The second is the research section and contains seven articles. Torsionally-Induced Stability in Spinors [4] deals with the problem of showing how torsion, creating a back-reaction between the spinor field and its spin, can quench the tendency to form singularities, whether they are gravitational, such as for the Hawking–Penrose theorem, or material, such

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as those encountered in quantum field theory. Detailed analyses are provided in Quantum Hydrodynamics of Spinning Particles in Electromagnetic and Torsion Fields [5] and Search for Manifestations of Spin-Torsion Coupling [6] by M. Trukhanova and co-workers, where axial vector spin–torsion coupling is investigated in general contexts, and additional effects of the torsion field are presented. A similarly general approach is also followed by C. Diether III and J. Christian in On the Role of Einstein-Cartan Gravity in Fundamental Particle Physics [7], where the authors examine the way in which torsion induces self-interactions for spinors that could balance the repulsive electrostatic forces of fermions. On the opposite side of the spectrum of applications, G. Milton in A Possible Explanation of Dark Matter and Dark Energy Involving a Vector Torsion Field [8] presents a model of torsion in gravity that could explain the dark sector of our Universe. Along the very same line, A. Ivanov and M. Wellenzohn tackle the problem of identifying the scalar field responsible for dark energy with the chameleon field in Can a Chameleon Field Be Identified with Quintessence? [9]. Finally, P. Asimakis and co-workers compare non-standard theories, such as types of teleparallel gravity against nucleosynthesis, in Big Bang Nucleosynthesis Constraints on $f(T, TG)$-Gravity [10].

With the last three papers on the dark sector and the previous three about the effects of torsion in particle physics, it is difficult to point to the direction in which torsion might make itself manifest. Every direction is open, and each is worthy of attention. For the purist, however, a spin density that is given by the Dirac field constitutes a very natural paradigm, and therefore I would be inclined to say that the phenomenologist might find the applications to quantum mechanics and particle physics to be those with higher discovery potential. However, as I said, every direction is open.

If, instead, you are a mathematical physicist, you may find Quantum Hydrodynamics of Spinning Particles in Electromagnetic and Torsion Fields [5] quite intriguing in its way of re-writing the full spinor theory in a form that is more suitable for formal manipulation, since in it the Dirac field is interpreted as a special type of spin fluid.

Those of you who are not new to torsion gravity may remember that a quarter of a century ago there was another Special Issue on torsion published by the Annales de la Fondation Louis de Broglie [11]. I authored a paper in that Special Issue and it pleases me immensely to be the Editor of the present Special Issue. However, for all the rest, the authorship has completely changed. Aside for me, not a single author from then has contributed now and this pleases me greatly too. It means that the torsion community is in constant renewal, with more ideas coming out afresh every year. It is my hope that younger generations will fuel the debate more than ever before.

But enough with the summary—you now know what you need to find the article that tickles your curiosity...

... Or just read them all to have a fair overview of the current state of torsion today.

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