Symposium Geometric Paradigms in Modern Physics (SYGP)

jointly organized by
Gravitation and Relativity Division (GR),
History of Physics Division (GP)
Theoretical and Mathematical Physics Division (MP)
Low Temperature Physics Division (TT), and
the Working Group on Philosophy of Physics (AGPhil)

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This year we celebrate the centennial of Einstein's theory of General Relativity. The idea of this symposium is to highlight the role of geometric ideas in different branches of modern physics and to relate these to the original as well as modern formulation of General Relativity. As is well known, many developments in modern field theories refer more or less directly to concepts we associate with, or have learned from, General Relativity and its geometric interpretation. We wish to explore in more detail the impact and success of such geometric concepts in various directions and to what extent this reference to General Relativity is helpful and truly justified.

Overview of Invited Talks and Sessions

(Lecture room: H 0105)

Invited Talks

SYGP 1.1	Thu	15:00–15:30	H 0105	**General relativity: a theory born in creative confusion** — •Harvey Brown
SYGP 1.2	Thu	15:30–16:00	H 0105	**Gravitating Non-Abelian Fields: Solitons and Black Holes** — •Jutta Kunz
SYGP 1.3	Thu	16:00–16:30	H 0105	**Geometric principles in the physics of topological matter** — •Alexander Altland
SYGP 1.4	Thu	16:30–17:00	H 0105	**General Covariance in Quantum Field Theory on Curved Spacetimes** — •Thomas-Paul Hack
SYGP 1.5	Thu	17:00–17:30	H 0105	**The (noncommutative) Geometry of the Standard Model of Particle Physics** — •Christoph Stephan

Sessions

SYGP 1.1–1.5	Thu	15:00–17:30	H 0105	**Geometric paradigms in modern physics**

SYGP 1: Geometric paradigms in modern physics

Time: Thursday 15:00–17:30 Location: H 0105

Invited Talk SYGP 1.1 Thu 15:00 H 0105
General relativity: a theory born in creative confusion — •Harvey Brown — Oxford University, Oxford, UK

A number of conceptual guiding principles were behind Einstein's development of general relativity; almost none of them proved to be completely sound. I will concentrate on the various ways Einstein interpreted Mach's Principle before finally abandoning it, and on the late adoption of the action-reaction principle in Einstein's promotion of his theory following correspondence with Moritz Schlick in 1920. The talk will be based on an article jointly published with Dennis Lehmkuhl: arXiv:1306.4902v1.

Invited Talk SYGP 1.2 Thu 15:30 H 0105
Gravitating Non-Abelian Fields: Solitons and Black Holes — •Jutta Kunz — University of Oldenburg

The Standard Model of Particle Physics involves non-Abelian fields describing the strong and electroweak interactions. The gauge and Higgs fields can form non-perturbative solutions in Minkowski spacetime. In the electroweak sector static finite energy solutions, sphalerons, are present, while no such solutions appear in the color sector. As soon as Einstein gravity is coupled, however, localized globally regular solutions appear. Moreover, hairy black hole solutions arise, i.e., black holes which are no longer uniquely determined by their global charges. Thus the black hole "no-hair" theorem of Einstein-Maxwell theory does not generalize to theories with non-Abelian fields. While all non-Abelian black holes obtained so far are axially symmetric, black holes with only discrete symmetries, e.g. platonic black holes, should exist as well. Moreover, multi-black hole solutions are expected to exist, where gravity and the non-Abelian forces should cancel, leading to balanced configurations.

Invited Talk SYGP 1.3 Thu 16:00 H 0105
Geometric principles in the physics of topological matter — •Alexander Altland — Institute for theoretical physics, Zülpicher Str. 77, 50937 Köln

'Topological matter' is the overarching term for novel classes of materials distinguished by the presence of robust topological invariants. Topological materials are distinguished by unconventional physical properties (most of which are rooted in the topological protection of their quantum states against decoherence) which make them promising candidates for applications in, e.g., quantum information, or quantum electronics.

In this talk, we will focus on the important subclass of topological insulators to explain how such properties can be understood from a geometric perspective. Starting from the description of a topological insulator's band structure in terms of fibre bundles, we will discuss how their physical properties emerge as a consequence of universal concepts, including Chern-Simons invariants, anomalies, dimensional reduction, topological field theories, and emerging 'holographic principles'.

Invited Talk SYGP 1.4 Thu 16:30 H 0105
General Covariance in Quantum Field Theory on Curved Spacetimes — •Thomas-Paul Hack — Department of Mathematics, University of Genoa

We highlight the role of general covariance in quantum field theory on curved spacetimes, and review how this principle is implemented at various steps in the perturbative construction of interacting models. We discuss conceptual and phenomenological consequences of the requirement of general covariance, which are of relevance e.g. in Cosmology.

Invited Talk SYGP 1.5 Thu 17:00 H 0105
The (noncommutative) Geometry of the Standard Model of Particle Physics — •Christoph Stephan — Institut für Mathematik, Universität Potsdam, Potsdam, Deutschland

In the past two decades Connes' Noncommutative Geometry has allowed to gain deeper insights into the geometrical foundations that underly General Relativity as well as the Standard Model of Particle Physics. A fascinating aspect of the theory is the close link between abstract mathematical concepts and experimentally measurable quantities.

The aim of my talk is to provide a basic introduction into the geometrical ideas of Noncommutative Geometry (spectral triples, Dirac operators, spectral actions, etc.) and to give a physical interpretation of the geometrical objects. Furthermore I will show how the notions of Particle Physics (and General Relativity) can be formulated within the framework of Noncommutative Geometry.

The central role in this construction is played by Dirac operators. Using the Connes-Chamseddine Spectral Action one can extract from these Dirac operators measurable physical quantities, for example the mass of the Higgs boson.