

# TOPOLOGICAL FIELD THEORY INTRODUCTION

**Fizyka Plus, Winter term 2014-2015, USOS code: 1100-3`TFT**  
**Tuesdays, 16:15-18:00 – Lecture room C223 (Faculty of Physics)**  
**Lecturer: Piotr Sułkowski (IFT FUW)**



Topological field theories provide one of the simplest examples of quantum field theories, and constitute a fascinating research area at the border of physics and mathematics. They are often exactly solvable and illustrate various fundamental phenomena, such as a role of topologically non-trivial solutions, non-perturbative effects, supersymmetry, etc. In physics, topological field theories find applications in condensed matter theory, quantum information, high energy, or string theory. From mathematical viewpoint they provide an important ground for rigorous formulation of quantum field theory, and at the same time are related to knot theory, low-dimensional topology, moduli spaces in algebraic geometry, etc. Several distinguished mathematicians and mathematical physicists, such as Donaldson, Jones, Witten, and Kontsevich, received Fields medals for their work related to topological field theory.

In this lecture the following topics will be discussed:

- various constructions of topological field theories: Schwarz-type, Witten-type
- basics of supersymmetry, supersymmetric quantum mechanics, Witten index
- localization, homological theories, topological twist
- Chern-Simons theory, elements of knot theory
- 't Hooft topological ("large  $N$ ") expansion for field theories and matrix models
- axiomatic formulation of topological field theories
- modern applications

The lecture should be accessible for second and third year students, as well as MSc students; it should also be of interests to PhD students and anyone interested in various relations between physics and mathematics. The knowledge of mathematical analysis and classical mechanics is required; the acquaintance with (at least) basics of quantum mechanics and classical field theory will be of advantage.