

## Preface

This volume collects the lecture series given at the *International Workshop on Noncommutative Geometry* that took place at the Institute for Studies in Theoretical Physics and Mathematics (IPM) in Tehran in 2005. The courses were addressed to graduate students and postdocs in both mathematics and physics. For this reason, the lectures provided different “points of access” to the field that are natural starting points for people with a background in physics, or in algebra and algebraic geometry, or in differential and Riemannian geometry. By topic the lectures can be roughly divided in three groups, which can be read independently, according to the specific interests of the readers.

A first combination of lectures deals with “operator algebras and differential noncommutative geometry”. The first contribution in this group is written by Masoud Khalkhali and introduces the basic tools of operator algebras, topological K-theory, cyclic cohomology, and Hopf cyclic theory. The second set of lectures in this group is by Alain Connes and Matilde Marcolli and is aimed at presenting an overview of the various different research directions in the field and a description of recent developments. These lectures are based on presenting many different sources of examples of noncommutative spaces, from physical systems, foliations, bad quotients, fractals, dimensional regularization, spacetime and particle physics, deformations of spectral geometries and of algebras, quantum groups, and noncommutative spherical manifolds. In addition to these examples, recent interactions between noncommutative geometry and number theory are discussed.

Another set of lectures can be grouped together under the theme of “categories and algebraic noncommutative geometry”. Among these, the lectures by Behrang Noohi give an introduction to the language of categories as an important tool for noncommutative geometry. These lectures cover basic material on abelian categories, categories of sheaves, Morita equivalences, complexes and derived categories, derived functors, triangulated categories,  $t$ -structures. The lecture series by Snigdhasyan Mahanta gives a brief introduction to algebraic noncommutative geometry in the sense of Artin, Tate and van den Bergh. Mahanta’s lectures as well as the lecture series by Jorge Plazas also give an overview of recent results of Polishchuk on algebraic models of noncommutative tori based on the category of holomorphic bundles on noncommutative tori embedded as a  $t$ -structure in the derived category of coherent sheaves on an elliptic curve,

as well as later developments along these lines. The Polishchuk construction presents a good example of a setting where a very nontrivial interplay between the differential and the algebraic approaches to noncommutative geometry takes place.

The volume also collects a set of lectures that are more directly focused on applications of noncommutative geometry to physics. The contributions to this part include a series of lectures by Richard Szabo on noncommutative field theories arising as states of D-branes in Type II superstring theories. Another set of lectures by Harald Grosse and Rainer Wulkenhaar discusses the renormalization of noncommutative quantum field theories. The lecture series by Giovanni Landi and Walter van Suijlekom gives an overview of the theory of instantons on noncommutative manifolds.

The lectures are meant to be accessible to advanced graduate students in either mathematics or theoretical physics. The volume stresses the interplay of analysis, differential and algebraic geometry, categorical constructions and physics in the context of noncommutative geometry.

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