| Module title | | | Abbreviation |
|---|---|---|---|
| **Introduction to Gauge/Gravity Duality** | | | 11-GGD-161-m01 |
| **Module coordinator** | | **Module offered by** | |
| Managing Director of the Institute of Theoretical Physics and Astrophysics | | Faculty of Physics and Astronomy | |
| **ECTS** | **Method of grading** | **Only after succ. compl. of module(s)** | |
| 8 | numerical grade | -- | |
| **Duration** | **Module level** | **Other prerequisites** | |
| 1 semester | graduate | -- | |

**Contents**

1. Elements of quantum field theory:
   - Quantisation of the free field
   - Interactions
   - Renormalisation Group
   - Gauge Fields
   - Conformal Symmetry
   - Large N expansion
   - Supersymmetry
2. Elements of gravity
   - Manifolds, coordinate covariance and metric
   - Riemann curvature
   - Maximally symmetric spacetimes
   - Black holes
3. Elements of string theory
   - Open and closed strings
   - Strings in background fields
   - Type IIB String Theory
   - D-Branes
4. The AdS/CFT correspondence
   - Statement of the correspondence
   - Near-horizon limit of D3-Branes
   - Field-operator correspondence
   - Tests of the correspondence: Correlation functions
   - Tests of the correspondence: Conformal anomaly
   - Holographic principle
5. Extensions to non-conformal theories
   - Holographic renormalisation group
   - Holographic C-Theorem
6. Applications I: Thermo- and hydrodynamics
   - Quantum field theory at finite temperature
   - Black holes
   - Holographic linear response formalism
   - Transport coefficients: Shear viscosity and conductivities
7. Applications II: Condensed matter physics
   - Finite charge density and Reissner-Nordström black holes
   - Quantum critical behaviour
   - Holographic fermions
   - Holographic superconductors
   - Entanglement entropy
8. Applications III: Particle physics
   - Gravity dual of confinement
   - Gravity dual of chiral symmetry breaking
   - Quark-gluon plasma

**Intended learning outcomes**

The students acquire a thorough understanding of the foundations of gauge/gravity duality and the ability to carry out basic tests. Depending on the pre-existing knowledge and interests of the students, the module addresses a selection of the aforementioned topics. Knowledge of quantum mechanics and classical electrodynamics is a prerequisite for this course. Knowledge of quantum field theory and general relativity is useful, but not a prerequisite.

**Courses** (type, number of weekly contact hours, language — if other than German)

V (4) + R (2)
Module taught in: German or English

**Method of assessment** (type, scope, language — if other than German, examination offered — if not every semester, information on whether module is creditable for bonus)

written examination (approx. 90 to 120 minutes) or oral examination of one candidate each (approx. 30 minutes) or oral examination in groups (groups of 2, approx. 30 minutes per candidate) or project report (approx. 8 to 10 pages) or presentation/talk (approx. 30 minutes).
If a written examination was chosen as method of assessment, this may be changed and assessment may instead take the form of an oral examination of one candidate each or an oral examination in groups. If the method of assessment is changed, the lecturer must inform students about this by four weeks prior to the original examination date at the latest.
Assessment offered: In the semester in which the course is offered and in the subsequent semester
Language of assessment: German and/or English

**Allocation of places**

--

**Additional information**

--

**Workload**

240 h

**Teaching cycle**

--

**Referred to in LPO I** (examination regulations for teaching-degree programmes)

--

**Module appears in**

Master's degree (1 major) Mathematics (2016)
Master's degree (1 major) Physics (2016)
Master's degree (1 major) Mathematical Physics (2016)
Master's degree (1 major) Computational Mathematics (2016)
Master's teaching degree Gymnasium MINT Teacher Education PLUS, Elite Network Bavaria (ENB) (2016)
Supplementary course MINT Teacher Education PLUS, Elite Network Bavaria (ENB) (2016)
Master's degree (1 major) Computational Mathematics (2019)
Master's degree (1 major) Mathematics (2019)
Master's degree (1 major) Physics (2020)
Master's teaching degree Gymnasium MINT Teacher Education PLUS, Elite Network Bavaria (ENB) (2020)
Supplementary course MINT Teacher Education PLUS, Elite Network Bavaria (ENB) (2020)
Master's degree (1 major) Mathematical Physics (2020)
Master's degree (1 major) Computational Mathematics (2022)
Master's degree (1 major) Mathematics (2022)
Master's degree (1 major) Mathematical Physics (2022)
exchange program Physics (2023)