**Module title**  
Topological Order

**Abbreviation**  
11-TOPO-161-m01

<table>
<thead>
<tr>
<th>Module coordinator</th>
<th>Module offered by</th>
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<tbody>
<tr>
<td>Managing Director of the Institute of Applied Physics</td>
<td>Faculty of Physics and Astronomy</td>
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<tr>
<th>ECTS</th>
<th>Method of grading</th>
<th>Other prerequisites</th>
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<tr>
<td>6</td>
<td>numerical grade</td>
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<tr>
<th>Duration</th>
<th>Module level</th>
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<tr>
<td>1 semester</td>
<td>graduate</td>
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**Contents**

Topologically ordered phases possess no order in the conventional sense (i.e., no broken symmetry and no local order parameter). The order is instead characterized by topological quantum numbers. In the course, the general concepts will be illustrated with the study of specific examples of systems with topological order. The topics discussed may include:

1. Fractional charge and statistics in quantized Hall fluids
2. Spin charge separation in spin chains and chiral spin liquids
3. Non-Abelian statistics of fractionalized excitations
4. Majorana zero modes in p-wave superconductors
5. Topological degeneracies on higher genus surfaces (e.g., torus geometry)
6. Spinons and visons in spin liquids including Kitaev models.

**Intended learning outcomes**

The students acquire in-depth knowledge of topological order in quantum condensates.

**Courses**

V (3) + R (1)  
Module taught in: German or English

**Method of assessment**

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**

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**Additional information**

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**Referred to in LPO I**

(examination regulations for teaching-degree programmes)

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**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)