# Symmetries

Perimeter Institute Summer School 2020

## Instructor information

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## Course description

The aim of this course is to  explore some of the many ways in which symmetries play a role in physics. We'll start with an overview of the concept of symmetries and their description in the language of  group theory. We will then discuss continuous symmetries and infinitesimal symmetries, their fundamental role in Noether's theorem, and their formalisation in terms of Lie groups and Lie algebras. In the last part of the course we will focus on symmetries in quantum theory and introduce representations of (Lie) groups and Lie algebras.

Each 90-minute session will include roughly equal amounts of lecture time and activities. The activities are designed to enhance your learning experience and allow you to assess your own level of understanding.

## Learning outcomes

By the end of this course students should be able to:

- Evaluate the symmetries of a Lagrangian or action functional and construct the associated Noether's charges/currents
- Construct the Lie algebras for the classical Lie groups and specify their structure constants
- Justify the appearance of spin in quantum mechanics from the point of view of representation theory

## Resources

These are some of the resources that we will use during the lectures/activities:

- [Socrative](#) and [Slido](#). These are online apps that we will use for activities. They don't need to be installed (they can run from a browser) and don't require an account.
- [GeoGebra](#). I will use this to show you interactive simulations or visualisations during the lectures, and I'll then share the applets I create with you. You can either use the online version or install it, which I recommend since it's a very useful piece of (open-source) software.

# Course schedule

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| **Lecture 1** | Overview/definition of symmetry, elements of group theory |
| **Lecture 2** | Continuous and discrete symmetries, infinitesimal symmetries |
| **Lecture 3** | Noether's theorem |
| **Lecture 4** | Lie groups and Lie algebras |
| **Lecture 5** | Representation theory, symmetries in quantum mechanics |