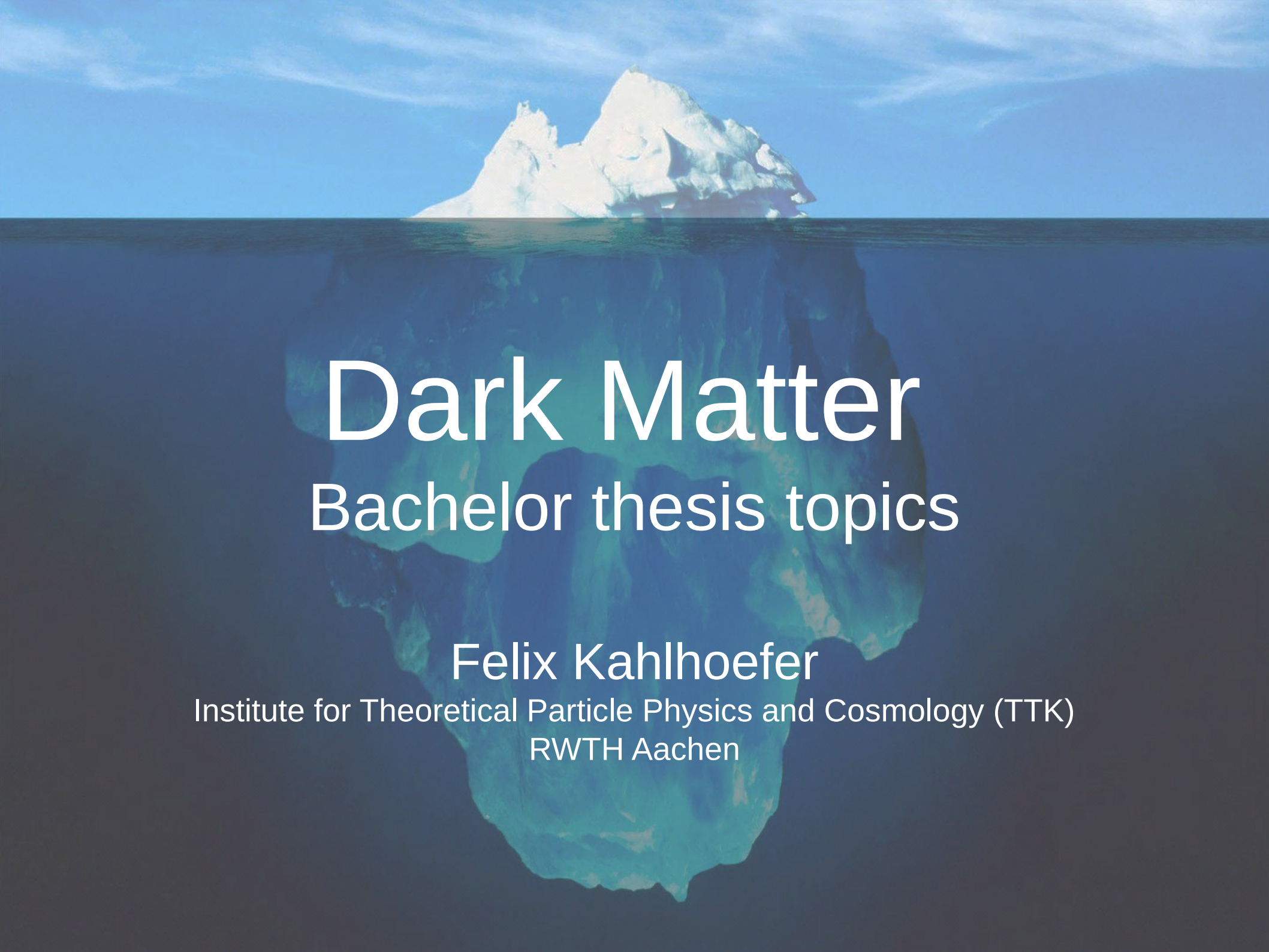

Dark Matter

Bachelor thesis topics

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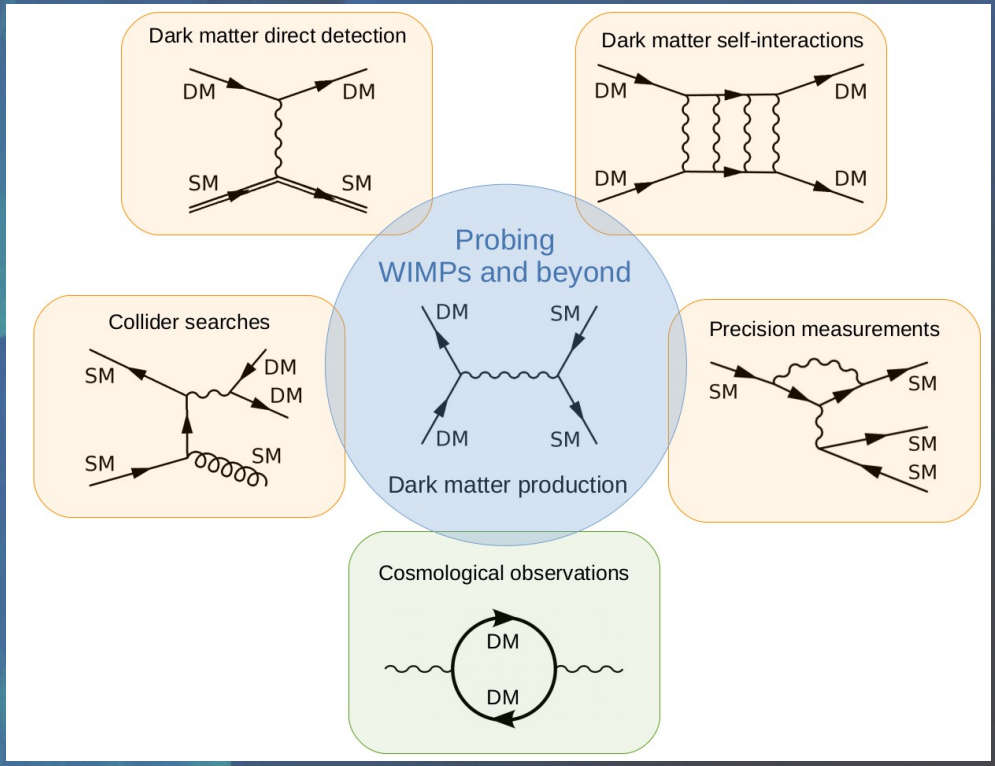
My research

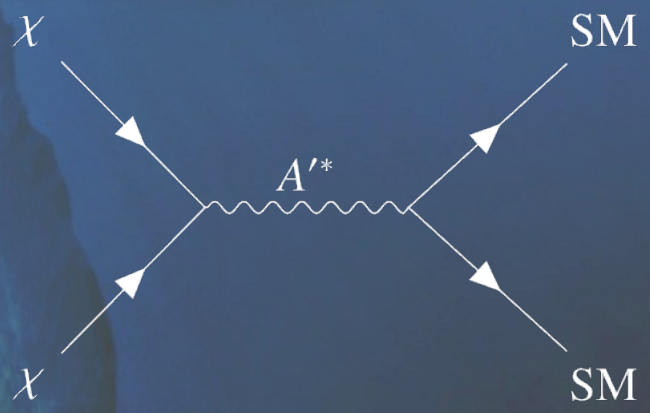
- Studying different models for dark matter and their phenomenological implications
- Combining information from particle physics, astrophysics and cosmology to search for dark matter
- Exploring the complementarity of different search strategies with global fits



- **More information:** https://web.physik.rwth-aachen.de/user/kahlhoefer/

Topic 1
Resonant dark matter annihilations in the early Universe

- The amount of dark matter that remains in the present Universe depends on how efficiently dark matter particles annihilate into Standard Model particles

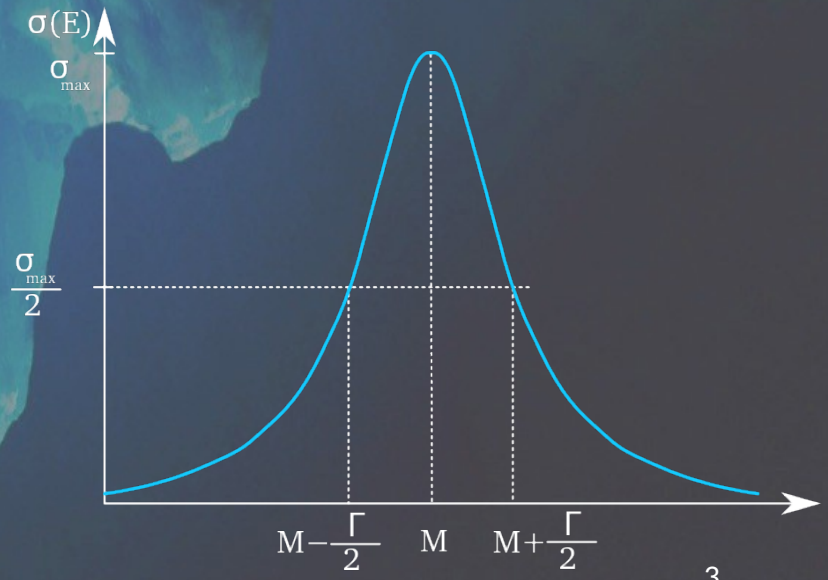


- Need to calculate the thermally averaged annihilation cross section

$$\langle \sigma v \rangle = \frac{2x}{K_2^2(x)} \int_0^\infty \sigma v \sqrt{\epsilon}(1+2\epsilon) K_1(2x\sqrt{1+\epsilon})\, \mathrm{d}\epsilon$$

- Easy in principle, but additional complications if annihilations can be resonantly enhanced

- Well-known results for Breit-Wigner resonances, but what if the shape of the resonance differs?



Topic 1
Resonant dark matter annihilations in the early Universe

Aims

- Become familiar with calculations of the freeze-out mechanism
- Calculate the thermally averaged cross section for resonant annihilations
- Write a numerical code to include corrections beyond the standard treatment

The student will learn

- How to describe the interactions of dark matter in the early Universe
- How to calculate thermal averages analytically and numerically
- How to accurately treat processes with resonant enhancement

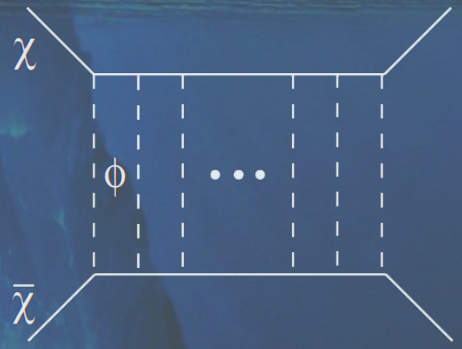
Requirements

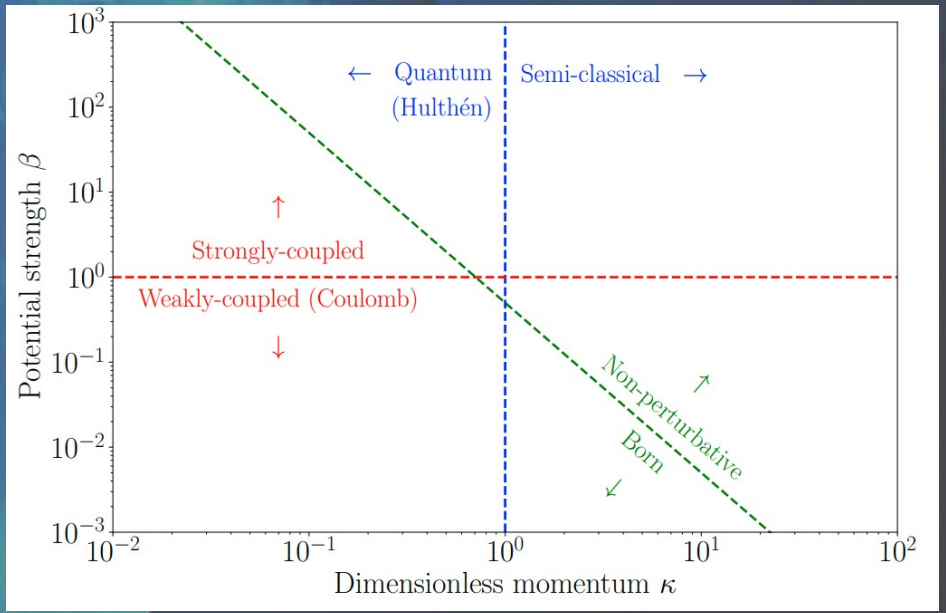
- General interest in particle physics and cosmology
- Some familiarity with python (or another programming language)

Topic 2

Semi-classical approximations for dark matter self-interactions

- Most research focuses on interactions between dark matter and known particles – what about dark matter self-interactions?
- Interactions of non-relativistic dark matter particles described by quantum mechanical scattering theory
- In certain cases possible to make semi-classical approximation
- Allows efficient calculation of cross sections for given form of the interaction potential
- Many possible applications!





Topic 2

Semi-classical approximations for dark matter self-interactions

Aims

- Become familiar with the calculation of scattering cross sections for non-relativistic particles in the classical limit and in quantum mechanics
- Derive suitable expressions for the intermediate “semi-classical” regime
- Calculate scattering cross sections for specific forms of the potential between dark matter particles

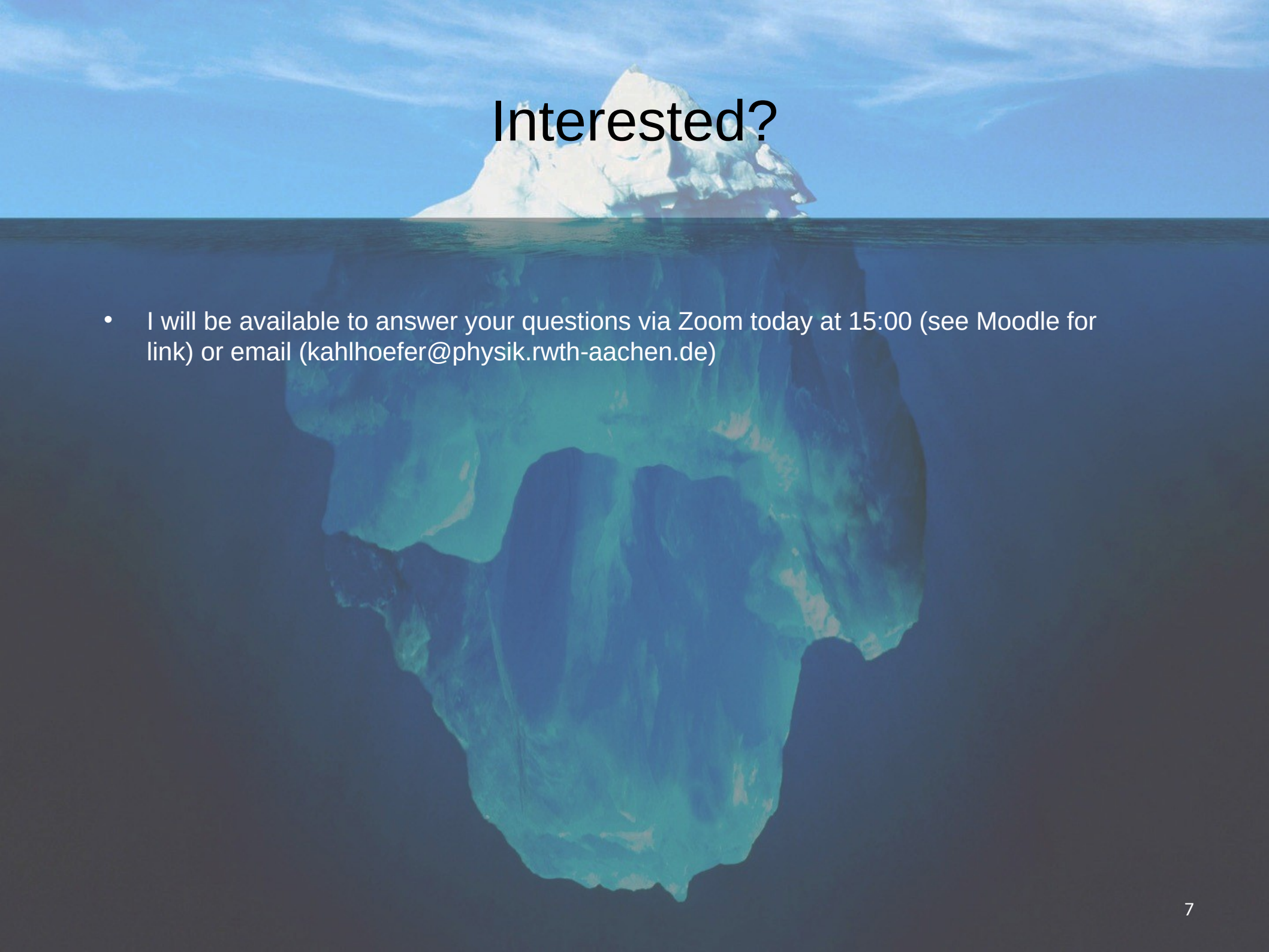
The student will learn

- How to calculate classical trajectories and quantum mechanical partial waves
- How to approximate quantum mechanical calculations in a semi-classical approach
- How to efficiently calculate and compare results obtained under different approximations

Requirements

- Strong interest in quantum mechanics and particle physics
- Necessary programming skills can be learned during the project

Interested?



- I will be available to answer your questions via Zoom today at 15:00 (see Moodle for link) or email (kahlhoefer@physik.rwth-aachen.de)