



# MASTER'S PROGRAMME IN THEORETICAL AND COMPUTATIONAL METHODS

Introduction to the students in the bachelor's programmes of the University of Helsinki



# MOTIVATION TO STUDY IN TCM - WHAT THE SOCIETY NEEDS?

- Well educated people able to solve problems
- Ethical and creative thinkers
- Project coordination skills
- Abilities to work in a team and independently

In TCM these are the "learning goals" of the entire degree.

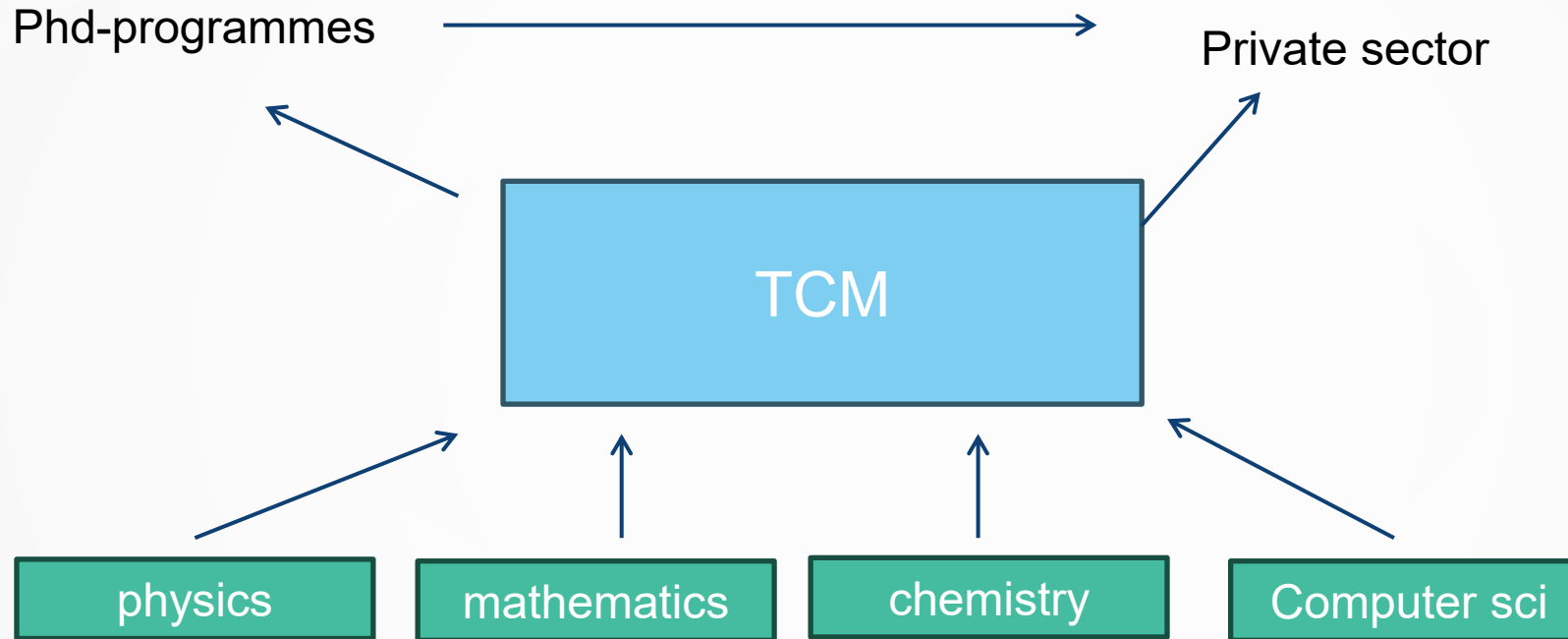
No study tracks.

A lot of freedom in building the degree content.

**Study planning and academic mentoring essential.**



# UNIQUE SKILLS PROFILES



**Main topic:** models in natural sciences

**Methodology** from theoretical physics, math, quantum physics and chemistry, numerical tools, computer and data science,...

**Overlaps** with many MSc programmes in physics, mathematics, chemistry, computer science

**Offers** flexible combination of studies in several different subjects



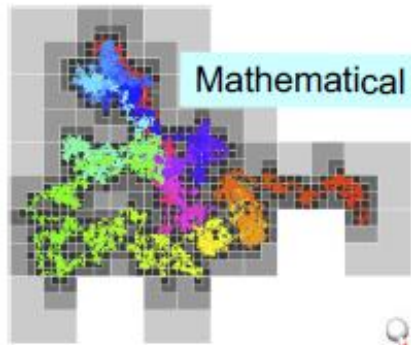
# FOCUS (PHYSICS) RESEARCH AREAS IN KUMPULA

Quantum science  
Atmospheric science,  
Material science,  
Particle physics,  
Cosmology,  
Astrophysics,  
Space physics,  
Biophysics,  
Nanophysics,  
...

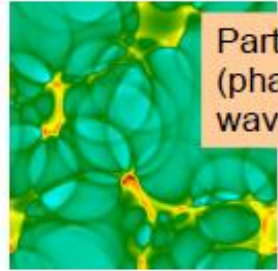


Research groups looking for:  
Experts in analytic and computational **methods**.

Some examples of research:



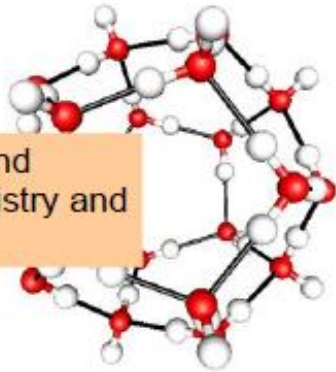
Mathematical physics



Particle physics and cosmology  
(phase transitions, gravitational waves)



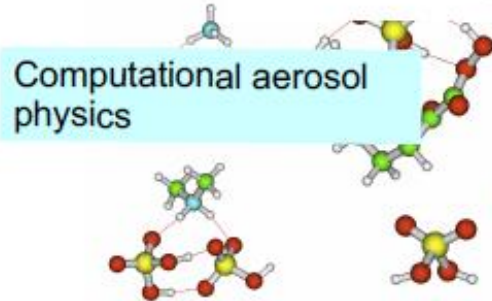
Computational materials physics



Computational and theoretical chemistry and spectroscopy



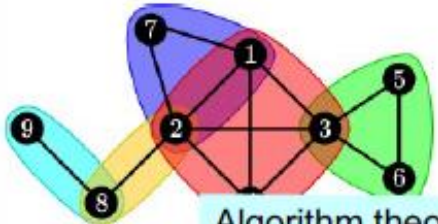
QCD and neutron star equation of state



Computational aerosol physics



Theoretical particle physics



Algorithm theory of computing



# STUDYING IN TCM

- No study tracks: studies are tailored according to student's interests via a *personal study plan (PSP)*
- If *starting a new subject*, start with key BSc courses.
- Selection of large number of courses available.

1. **year:** The tailored *PSP + 60| ects* courses  
.. **end:** Find a MSc thesis topic and main supervisor

2. **year:** Seminar + courses (*25 ects*) + write thesis

quantum physics

statistical physics

particle physics  
& cosmology

condensed  
matter physics

Atmospheric  
sciences

mathematical  
physics

functional analysis  
& spectral theory

applied analysis &  
partial diff. equations

stochastic analysis

algebraic &  
topological methods

programming &  
numerical methods

computer science

data science

chemistry



# YOUR DEGREE IN TCM

## Your degree will include:

- **90-120 cr of advanced courses** including
  - 35 cr of compulsory studies (Master's thesis, seminar, and maturity test)
  - 55-85 cr of optional advanced studies  
The optional advanced studies can include whole course packages or individual courses related to your field of interest and as agreed with your academic mentor.
- **0-30 credits of other courses** from TCM or other programmes
  - Other studies may include study modules or individual courses from other degree programmes to meet the minimum total number of credits required for your degree. Also practical training and language studies can be included.
- [Degree structure of TCM](#)



# EXAMPLE STUDY PATHS

- Example study paths:

- Chemistry and biophysics
- Numerical space physics
- Machine learning and statistics
- Materials physics
- Quantum algorithms & information
- Quantum core
- Data science for cosmology and the early universe

Course code	Course name	Level	Credits	Lectured	Comments
<b>1. year, fall 2025</b>					
PAP332	Introduction to particle physics I	advanced	5	every year (1)	
FYS2081	Cosmology I	intermediate	5	every year (1)	
DATA11001	Introduction to data science	advanced	5	every year (1)	
DATA11002	Introduction to machine learning	advanced	5	every year (2)	This course will be replaced by DATA11010 Machine Learning 1 in fall 2026.
LSI35002	Bayesian data analysis	advanced	5	every year (2)	
FYS2085	Scientific computing II	intermediate	5	every year (2)	
<b>1. year, spring 2026</b>					
TCM302	Quantum mechanics IIa	advanced	5	every year (3)	
PAP348	General relativity I	advanced	5	every year (3)	
TCM303	Quantum mechanics IIb	advanced	5	every year (4)	
PAP349	General relativity II	advanced	5	every year (4)	
DATA12001	Advanced course in machine learning	advanced	5	every year (4)	This course will be replaced by DATA11011 Machine Learning 2 in spring 2027.
	A course from another programme				
<b>2. year, fall 2026</b>					
TCM327	Quantum field theory I	advanced	5	every year (1)	
MAST32001	Computational statistics	advanced	5	every year (1)	
TCM328	Quantum field theory II	advanced	5	every year (2)	
PAP326	Cosmology II	advanced	5	every year (2)	
	A course from another programme				
<b>2. year, spring 2027</b>					
TCM307	Seminar in Theoretical and Computational Methods	advanced	5	every year (1-4)	Discuss the seminar practicalities with your thesis supervisor or academic mentor. Register to the course and start attending the seminars already in fall 2026. The seminar course runs throughout the year (periods 1-4). The course should be completed in spring 2027.
TCM350	Master's thesis	advanced	30		Plan scheduling of your Master's thesis already when you draw up your personal study plan (PSP) in the beginning of your Master's studies.
TCM399	MSc maturity test	advanced	0		



# QUANTUM SCIENCE & QUANTUM TECHNOLOGIES – YOUR DEGREE COULD LOOK LIKE THIS

## OPTIONAL COURSES (55-85 cr)

### THEOR./ MATH. PHYS

Quantum mechanics IIa TCM302 (5cr)  
Quantum mechanics IIb TCM303 (5cr)  
Quantum information A TCM322 (5cr)  
Quantum information B TCM323 (5cr)  
Open quantum systems I TCM333 (5 cr)  
Open quantum systems II TCM334 (5 cr)

### Computer science:

Design and Analysis of Algorithms  
CSM12101 (5 cr)  
Approximation Algorithms CSM12106 (5 cr)  
Combinatorial Optimisation CSM12107 (5  
cr)  
Randomised Algorithms CSM12126 (5 cr)  
Algorithms in genome analysis LSI31007 (5  
cr)

### Data Science

Data Science DATA1101 (5cr)  
Machine learning 1 DATA1010 (5cr)  
Machine learning 2 DATA1011 (5cr)  
Computational statistics I MAST32001  
(5cr)

**COMPULSORY COURSES (35  
cr)** MSc thesis (30 cr) + seminar  
(5 cr)

**OTHER STUDIES (0-30 cr)**  
Quantum mechanics I FYS2018  
(5cr) Quantum computing  
FYS2029 (5cr) Scientific  
computing II FYS2085 (5cr)



# CROSS-INSTITUTIONAL STUDIES

- It is possible to take certain courses of other Finnish universities as cross-institutional studies.
- At the moment, three cross-institutional studies agreements concern TCM students:
  - Chemistry (University of Helsinki and Aalto University)
  - Physical chemistry (University of Helsinki and University of Jyväskylä)
  - Quantum science and technology (University of Helsinki and Aalto University)
- [More information and registration instructions](#)



# TO CONTINUE INTO TCM FROM DIFFERENT BACHELOR'S PROGRAMMES:

**Fysikaalisten tieteiden kandiohjelma, Kemian kandiohjelma, Tietojenkäsittelytieteen kandiohjelma, Matemaattisten tieteiden kandiohjelma**

Näistä ohjelmista siirtyvien opiskelijoiden tulee suorittaa kandiopintojensa aikana seuraavat opinnot:

- vähintään 15 op aineopintoja yhdeltä tai useammalta seuraavista aloista (pl. opiskelijan kandiopintojen ala): fysiikka, kemia, matematiikka tai tietojenkäsittelytiede (ml. hyväksiluetut opinnot ko. aloilta)
- TAI opintojaksot FYS2012 Fysiikan matemaattiset menetelmät Ila ja FYS2013 Fysiikan matemaattiset menetelmät IIb sekä FYS2085 Tieteellinen laskenta II
- TAI opintojaksot FYS2012 Fysiikan matemaattiset menetelmät Ila ja FYS2013 Fysiikan matemaattiset menetelmät IIb sekä Ohjelmoinnin jatkokurssi

## **Bachelor's programme in science**

- at least 15 ECTS **intermediate studies** in one or more of the following fields, but excluding the field of your study track: chemistry, computer science, mathematics, or physics (including credits transferred by substitution or inclusion)
  - OR the courses Mathematical Methods of Physics Ila & IIb and Scientific Computing II
  - OR the courses Mathematical Methods of Physics Ila & IIb and Advanced Course in Programming



# WHAT TO DO AFTER YOU DEGREE?

- Many continue with PhD studies after the MSc degree
- A typical way is to do your MSc thesis for a research group and continue with PhD studies. A typical way to start the MSc work is the summer internship in a research group during the summer
- Career opportunities outside academia for experts in analytic and computational methods.
  - Research and development
  - Consulting and managerial jobs
  - Data scientist and programmer jobs
  - e.g.



# MAIN CONTACT PERSONS IN TCM

- Esko Keski-Vakkuri (director) theoretical/mathematical physics
- Susi Lehtola computational/quantum chemistry (vice-director)
- Bernhard Reischl atmospheric sciences
- Ilja Makkonen condensed matter physics
- Paolo Muratore-Ginanneschi mathematics and statistics (+ InstituteQ)
- Kai Puolamäki data science & computer science
- Vivek Sharma biophysics & chemistry

Student members: Olavi Kiuru and Tian Li