UNIVERSITY OF HELSINKI https://www.helsinki.fi/en/programmes/master/data-science

NEWS STUDYING RESEARCH PEOPLE CONTACT

# MSc PROGRAMME in DATA SCIENCE

Prof. Jussi Kangasharju
Programme Director

## HOW TO PREVENT SHIPWRECKS WITH THE HELP OF BIG DATA?

Data science combines computer science and statistics to solve exciting data-intensive problems in industry and in many fields of science. As data is collected and analysed in all areas of society, demand for professional data scientists is high and will grow higher. This interdisciplinary Data

Harvard Business Review

DATA

# Data Scientist: The Sexiest Job of the 21st Century

by Thomas H. Davenport and D.J. Patil

FROM THE OCTOBER 2012 ISSUE

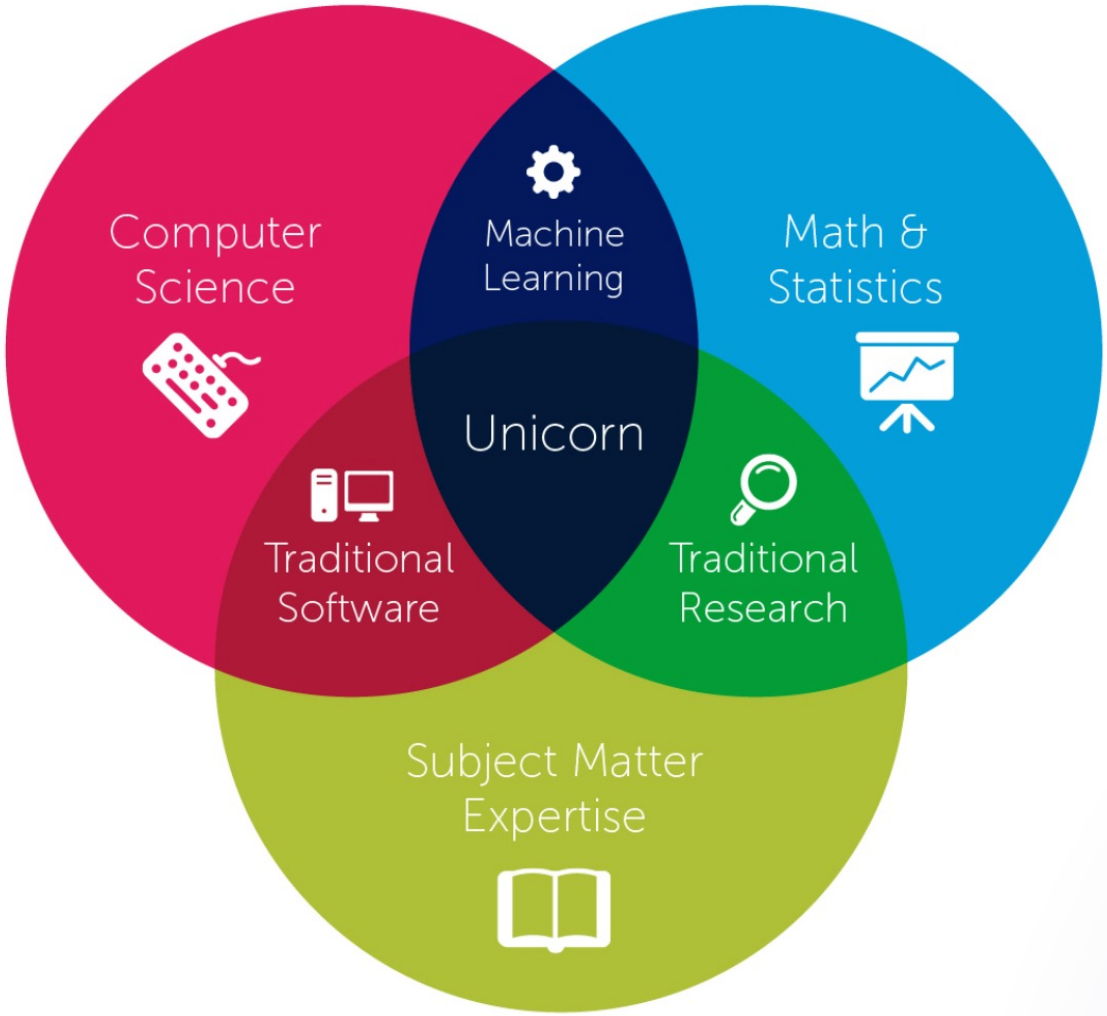
SUMMARY | SAVE | SHARE | 6 COMMENT | HH TEXT SIZE | PRINT | $8.95 BUY COPIES

When Jonathan Goldman arrived for work in June 2006 at LinkedIn, the business networking site, the place still felt like a start-up. The company had just under 8 million accounts, and the number was growing quickly as existing members invited their friends and colleagues to join. But users weren't seeking out connections with the people who were already on the site at the rate executives had expected. Something was apparently missing in the social experience. As one LinkedIn manager put it, "It was like arriving at a conference reception and realizing you don't know anyone. So you just stand in the corner sipping your drink—

# Tasks of a data scientist (O'Reilly Data Science Salary Survey 2017)

1. Basic exploratory data analysis
2. Conduct data analysis to answer research questions
3. Communicate findings to business decision-makers
4. Data cleaning
5. Develop prototype models
6. Create visualizations
7. Identify business problems that can be solved with analytics

# Data Science = Extraction of knowledge from data



# Data Science MSc Programme

- Combination of Computer Science and Statistics
- Room for minor studies also in other fields
- The programme started in 2017
- Teaching language: English
- Currently around 150 students in the programme
- Number of international applicants rising:
  - 84 (2017) -> 155 -> 278 -> 355 -> 573 (2021)

# Entry requirements for Kumpula BSc students

- Check student guide for exact requirements
- Certain courses need to be included in your BSc

- Short summary of **required skills**:
  - Programming, data structures and algorithms
  - Probabilities and statistics
  - **Linear algebra**, calculus, some other math

- Mathematics for Machine Learning I + II
  - Highly recommended courses
  - Not a replacement for required courses

# Required courses in BSc

- Computer science:
  - MAT12003 Todennäköisyyslaskenta I and 5 cr statistics (e.g., MAT12001 Tilastotiede tutuksi ja R-ohjelmisto or MAT12004 Tilastollinen päättely I)
- Mathematics:
  - 10 cr of programming (e.g., TKT10002 and TKT10003)
- Physics:
  - Ohjelmoinnin jatkokurssi TKT10003 or Tieteellinen laskenta II
- Bachelor of Science:
  - CS+DS track: No additional courses
  - Other tracks: MAT12003 Probability calculus I

# MSc degree content
# Overview

1. Compulsory courses (35 cr)
2. Specialization courses (at least 20 cr)
3. MSc thesis (30 cr)
4. Other studies (up to 35 cr)
   - Can be data science or anything

# MSc degree content
# Compulsory courses (35 cr)

- Introduction to Data Science
- Introduction to Machine Learning
- Distributed Data Infrastructures
- Bayesian Data Analysis
- Academic Skills for Data Science
- Data Science Project
- Data Science Seminar

# MSc degree content
# Specialization courses (>= 20 cr)

At least four courses, in these broad areas:

- Machine learning and algorithms
- Statistical data science
- Data science infrastructures
- Computer and cognition
- Interdisciplinary data science

# Welcome to the Data Science MSc Programme!

# THEORETICAL AND COMPUTATIONAL METHODS

What the programme is about?

Briefly about studying in TCM

Career opportunities?

How to get in.

Contacts and links for more info.

Kimmo Tuominen 22.3.2021

HOW DID WE GET HERE FROM THE BIG BANG?

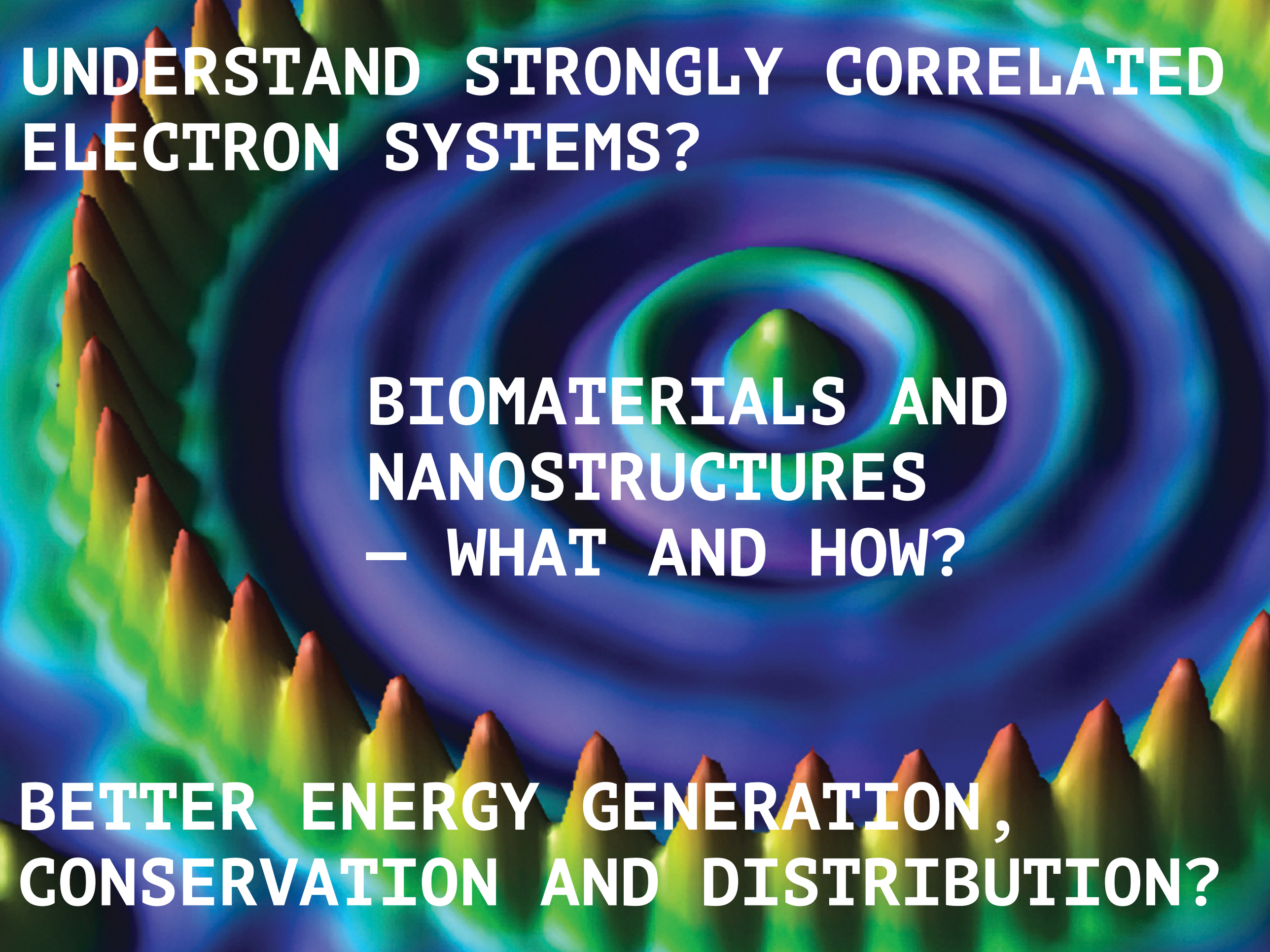
WHAT CONSTITUTES 80% OF ALL MATTER?

CAN WE DETECT DARK MATTER IN THE LAB?

HOW PARTICLES CLUSTER IN THE ATMOSPHERE?

CHEMISTRY OF AIR POLLUTION?

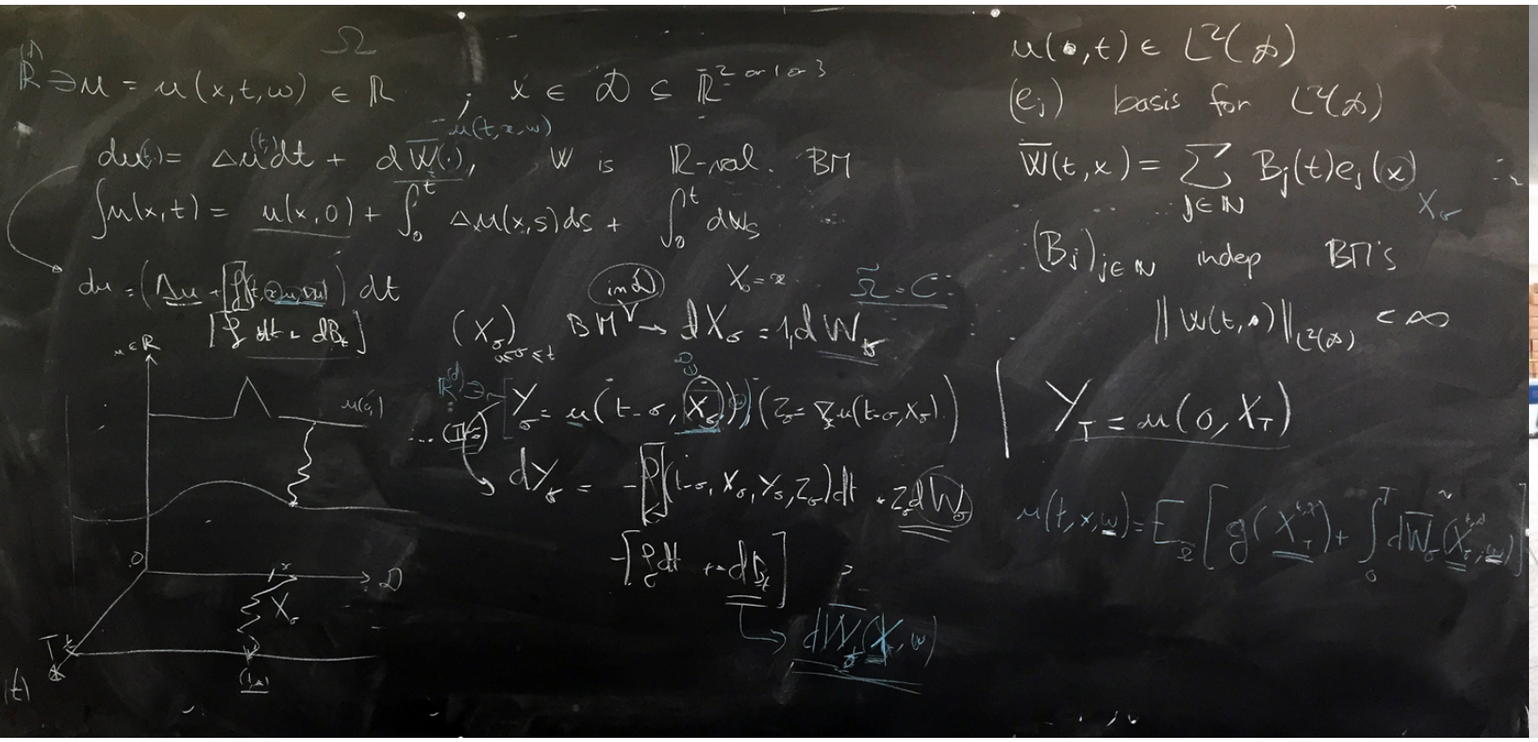
PREDICTING WEATHER, SIMULATING CLIMATE?


UNDERSTAND STRONGLY CORRELATED ELECTRON SYSTEMS?
BIOMATERIALS AND NANOSTRUCTURES – WHAT AND HOW?
BETTER ENERGY GENERATION, CONSERVATION AND DISTRIBUTION?

# BIG QUESTIONS are everywhere!

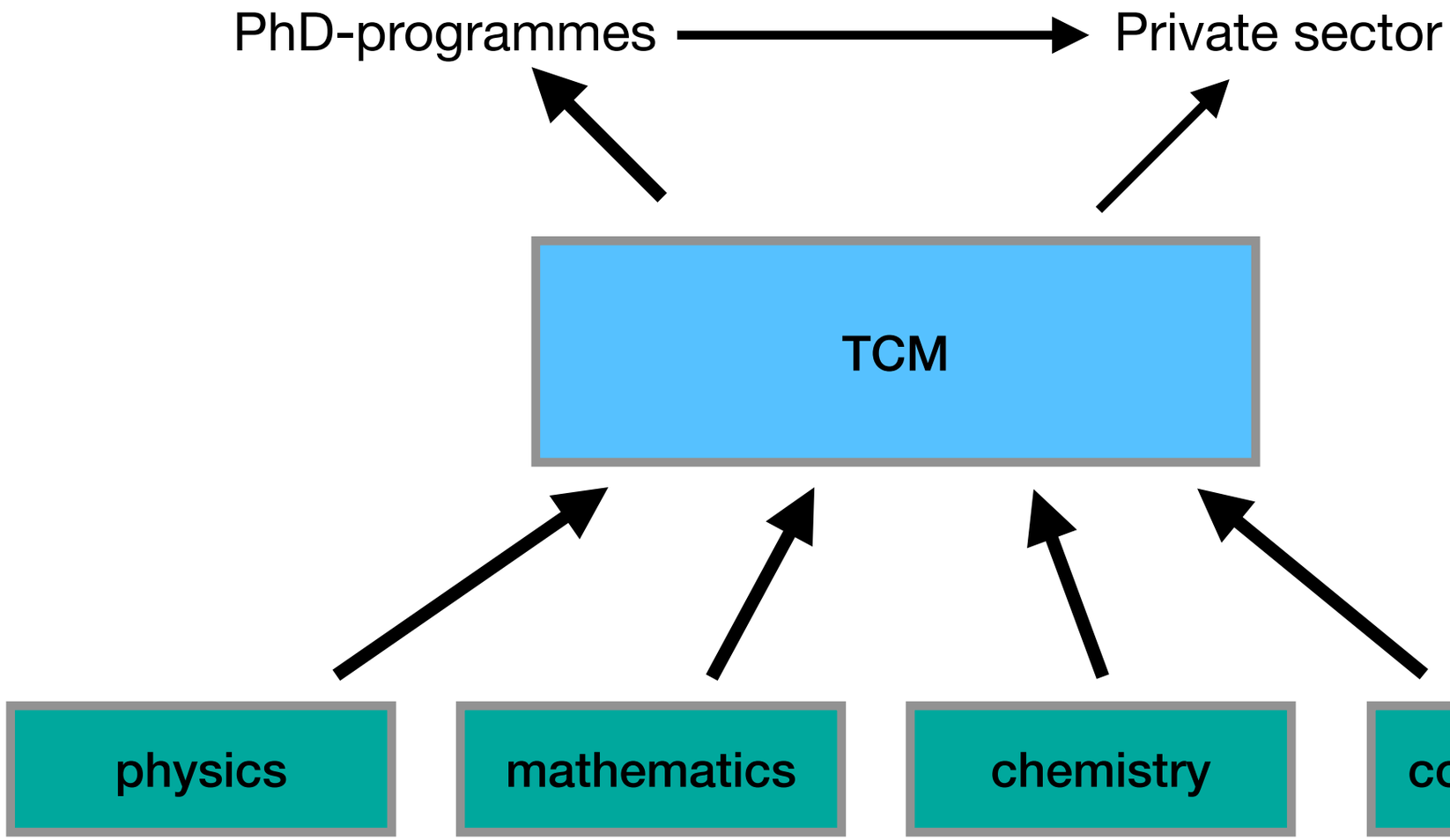
Can we crack the code for ANSWERS ?

# Where do mathematical/ theoretical/ computational (physicists) scientists go?



Master’s programme in

## Theoretical & Computational methods (TCM)




**Main topic:** models in natural sciences

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

**Overlaps** with many MSc programmes in phys, math, them, comp. sci.

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

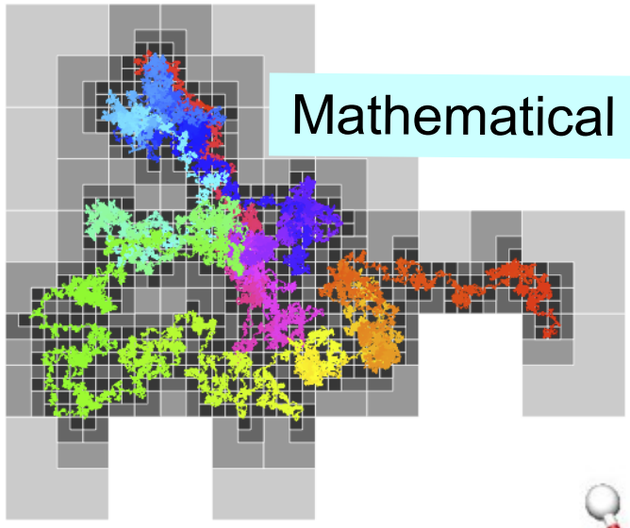
⇒ ***unique skill profiles***

# Focus (physics) research areas in Kumpula

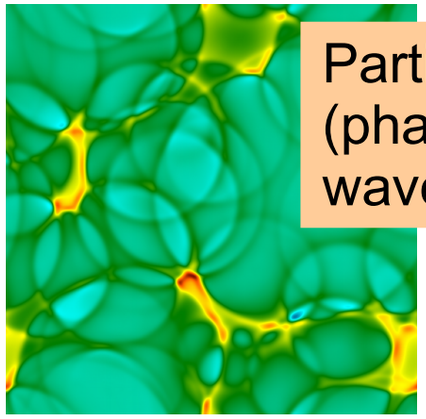
Atmospheric science,
Material science,
Particle physics,
Cosmology,
Astrophysics,
Space physics,
Biophysics,
Nanophysics,
....

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

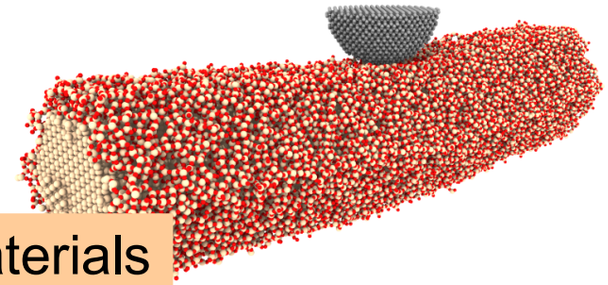
Some examples of research:



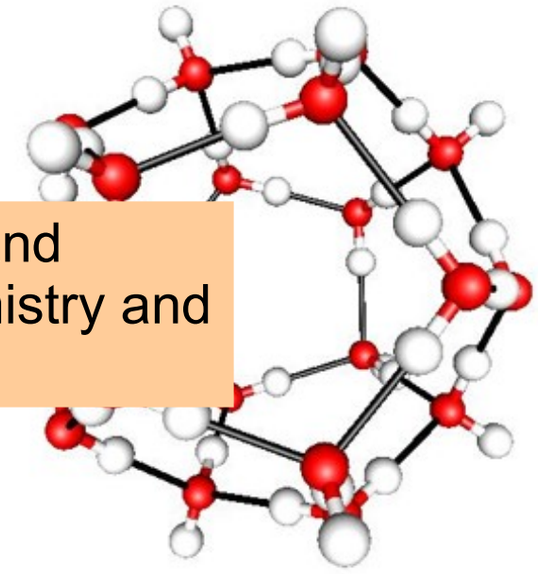
Mathematical physics



Particle physics and cosmology (phase transitions, gravitational waves)



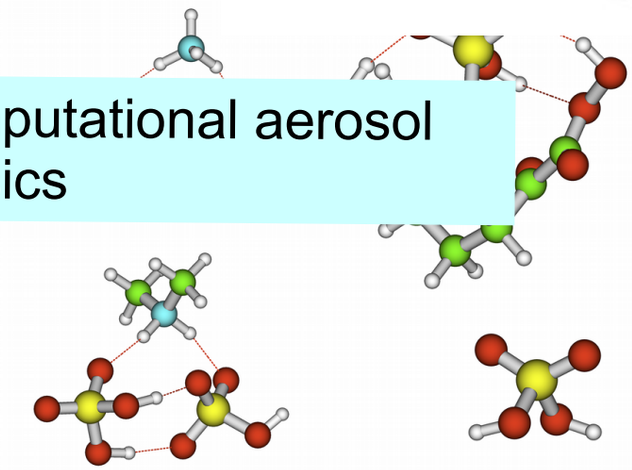
Computational materials physics



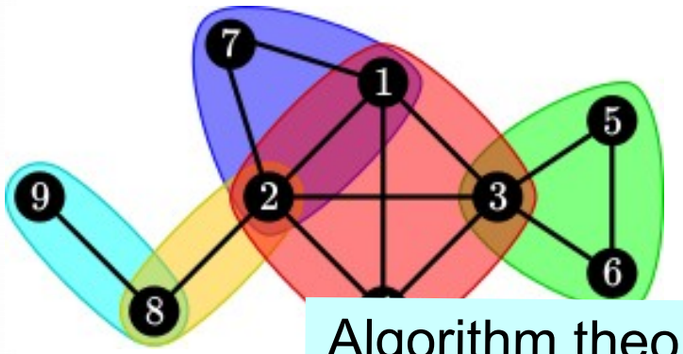
Computational and theoretical chemistry and spectroscopy

QCD and neutron star equation of state

Theoretical particle physics



Computational aerosol physics




Algorithm theory of computing

# Studying in TCM

- No "study lines": 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.

| | | |
|---|---|---|
| **quantum physics** | **mathematical physics** | **programming & numerical metods** |
| **statistical physics** | **functional analysis & spectral theory** | **computer science** |
| **particle physics & cosmology** | **applied analysis & partial diff. equations** | **data science** |
| **condensed matter physics** | **stochastic analysis** | **chemistry** |
| **Atmospheric sciences** | **algebraic & topological methods** | |

**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

e.g. **Quantum science & quantum technologies**

**OPTIONAL COURSES (55-85 cr)**

THEOR./ MATH. PHYS
Quantum mechanics IIa TCM302 (5cr)
Quantum mechanics IIb TCM303 (5cr)
Quantum information Ia TCM322 (5cr)
Quantum information Ib TCM323 (5cr)
Open quantum systems TCM315 (10 cr)

CS
Design and analysis of algorithms CSM12101 (5cr)
Approximation algorithms CSM12106 (5cr)
Randomized Algorithms I CSM12104 (5cr)
Randomized Algorithms II CSM12105 (5cr)
Combinatorial optimisation CSM12107 (5cr)

DATA
Intro to data science DATA1101 (5cr)
Intro to machine learning DATA11002 (5cr)
Advanced course in machine learning DATA12001 (5cr)
Computational statistics I MAST32001 (5cr)

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

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

Career opportunities outside academia for experts in analytic and computational **methods.**

**e.g.**

**Research and development**

**Consulting and managerial jobs**

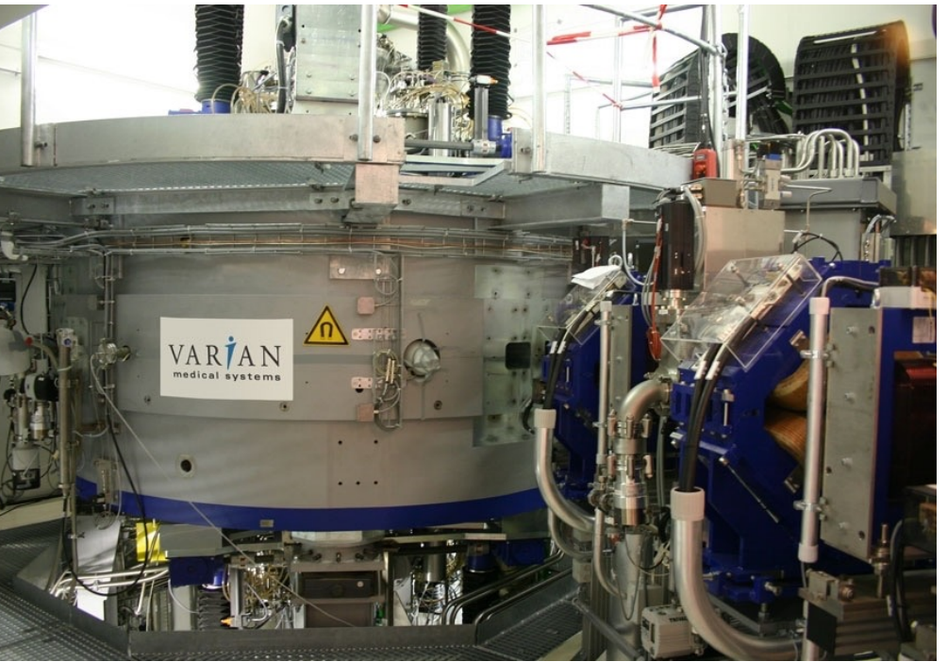
**Data scientist and programmer jobs**

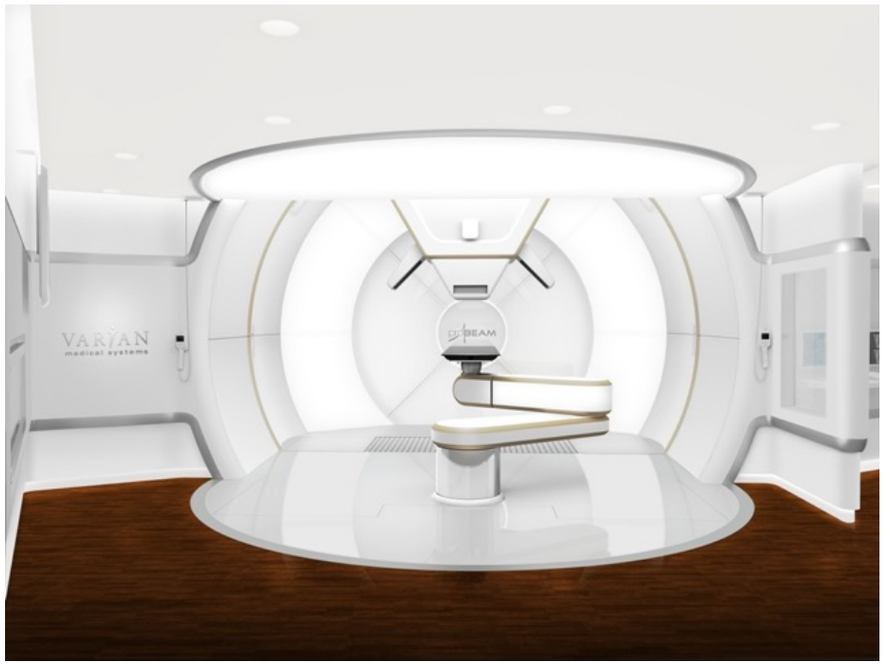
*Quintiq:* solving the world's planning, scheduling and supply chains

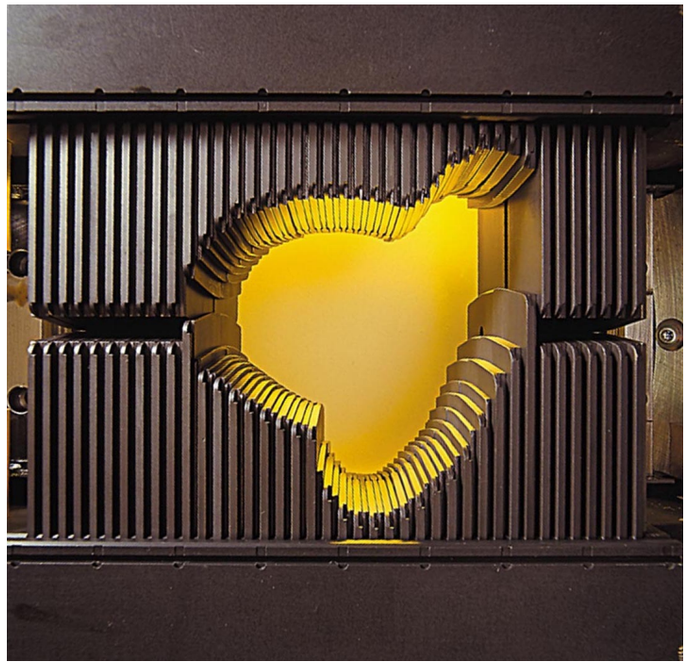
**(Wärtsilä)**

*Eniram:* reducing consumption and emissions, increasing savings

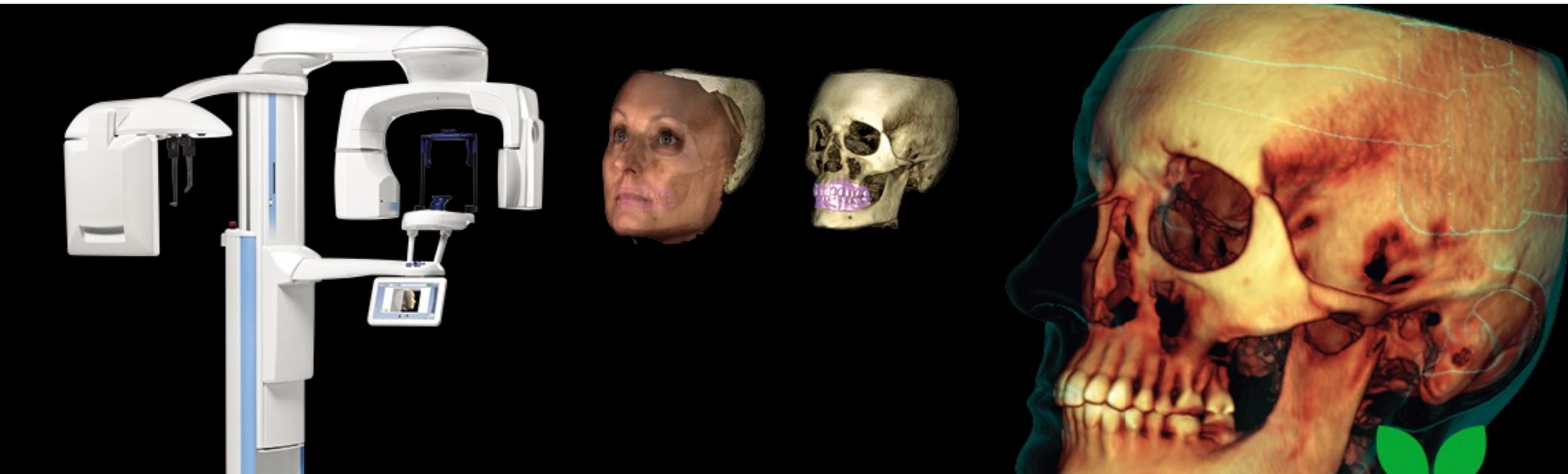
# *Varian medical systems:* fighting cancer,  X-ray imaging



# *Planmeca:* ultra low dose, high quality imaging



## To get into TCM from different bachelor programmes:

**Fysikaalisten tieteiden kandiohjelma:**
FyMM IIa & B ja Tieteellinen laskenta II tai ohjelmoinnin jatkokurssi.

**Kemian kandiohjelma:**
15 op fysiikan, matematiikan tai tietojenkäsittelytieteen opintoja.

**Tietojenkäsittelytieteen kandiohjelma:**
Matematiikan perusopinnot ja vähintään 15 op fysiikan tai kemian opintoja (muita kuin matemaattisten menetelmien opintoja)

**Matematiikan kandiohjelma:**
15 op fysiikan tai kemian opintoja
(muita kuin matemaattisten menetelmien opintoja.

**Bachelor programme in science:**
At least 15 eats of studies in *another* study track of the programme, listed in Basic of Subject studies module and excluding BS1000 module.

# Programme steering group

Director: Kimmo Tuominen
Vice Director: Mikko Koivisto

Ainhoa Hernandez Serranho
Antti Kuronen
Paolo Muratore-Ginanneschi
Olli Pakarinen
Vivek Sharma
David Weir
Ronja Öhrnberg

Education coordinator:
Tiina Hasari

kimmo.i.tuominen@helsinki.fi

tiina.hasari@helsinki.fi

**https://...**
(https://www2.helsinki.fi/fi/opiskelijaksi/koulutusohjelmat/theoretical-and-computational-methods-masters-programme)

**TCM infowiki**
(https://wiki.helsinki.fi/display/TCMWiki/TCM+Master%27s+Programme%3A+unofficial+infopages)

**Degree structure**
(https://wiki.helsinki.fi/pages/viewpage.action?pageId=287943475)

# GEOGRAPHY MSC PROGRAMME

HELSINGIN YLIOPISTO
HELSINGFORS UNIVERSITET
UNIVERSITY OF HELSINKI

# GEOGRAPHY MSC PROGRAMME

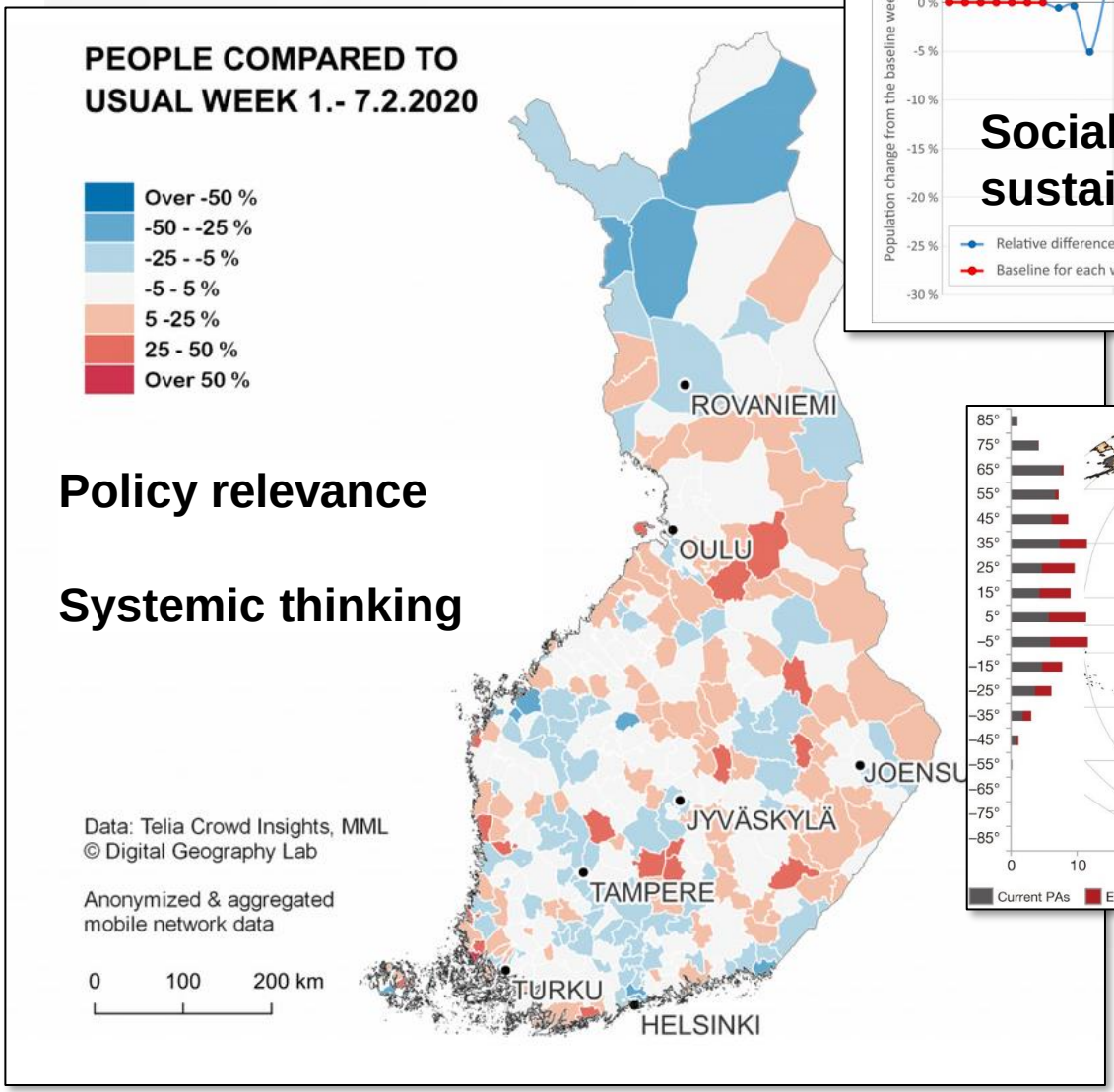
HELSINGIN YLIOPISTO
HELSINGFORS UNIVERSITET
UNIVERSITY OF HELSINKI

# 1. SOME BACKGROUND

# OLD FIELD OF STUDY AT THE UNIVERSITY OF HELSINKI

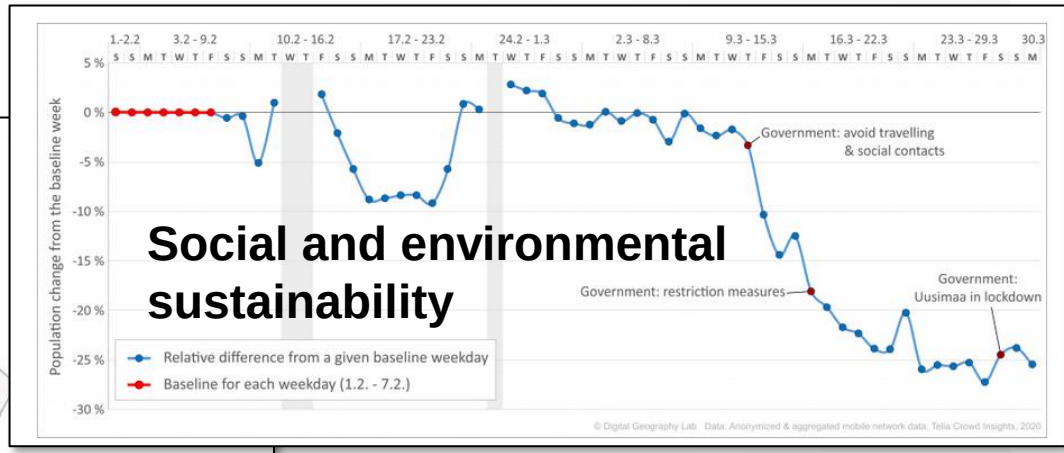
**Kuva 3**. Maantieteen laitoksen opiskelijoita kenttätutkimusmenetelmiin tutustumassa prof. Rosbergin (takarivissä toinen oikealta) johdolla Eläintarhan alueella Helsingissä vuonna 1901.

# INCREASINGLY TOPICAL TODAY

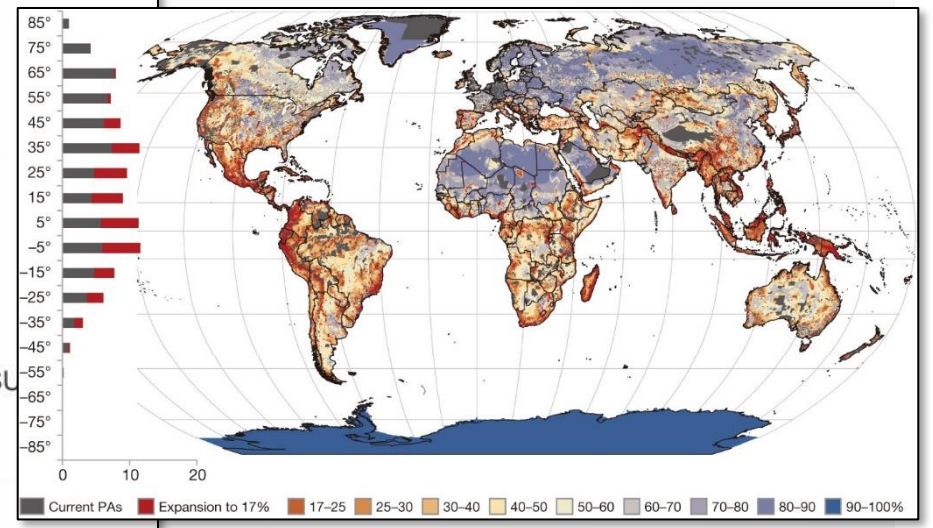



**Policy relevance**

**Systemic thinking**




**Social and environmental sustainability**




**Global and local complex questions**

## SOCIAL AND SPATIAL INTERACTIONS

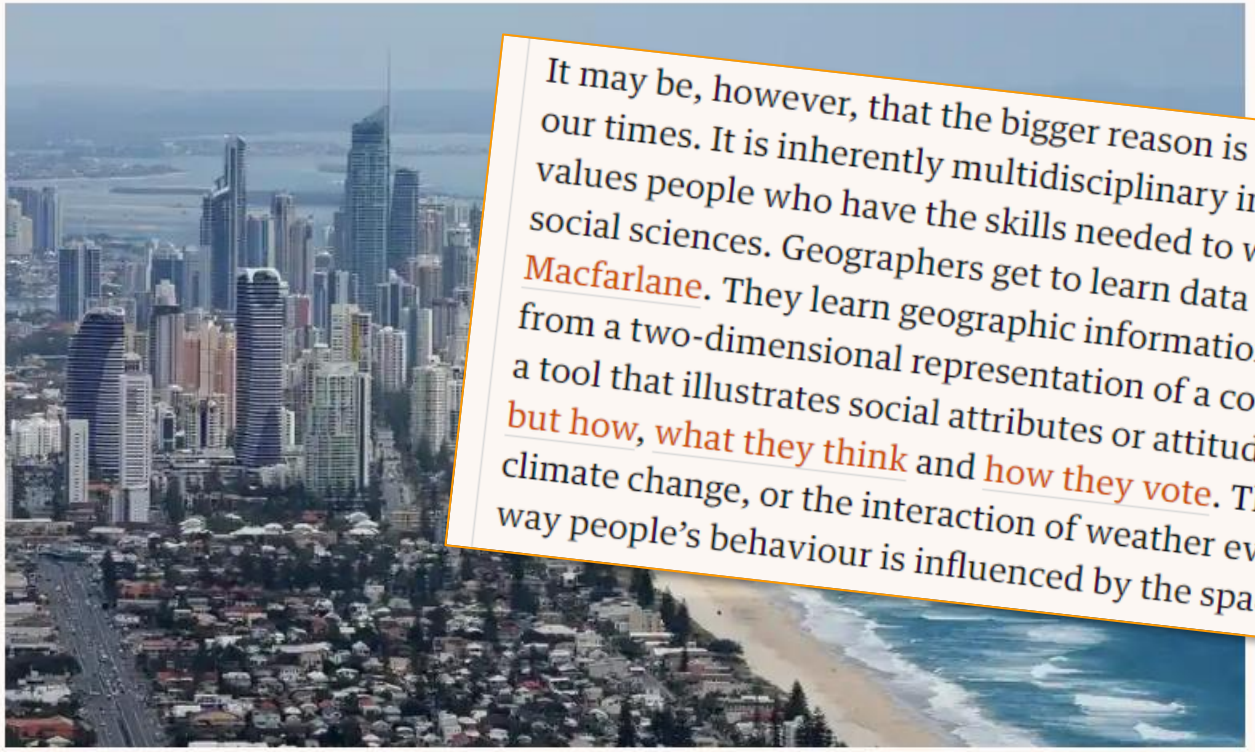
## HUMAN-NATURE INTERACTIONS

**Geographical understanding and methods**

# The Guardian view on geography: it's the must-have A-level

*Editorial*

It used to be a Cinderella subject. Now, in a world that increasingly values people who can work across the physical and social sciences, geography's all the rage



▲ 'Geographers learn about the physics of climate change, or the interaction of weather events and flood risk, or the way people's behaviour is influenced by the space around them.' Above, Surfers Paradise, on the Gold Coast, Australia. Photograph: Chris Hyde/Getty Images

It may be, however, that the bigger reason is that geography is a subject for our times. It is inherently multidisciplinary in a world that increasingly values people who have the skills needed to work across the physical and social sciences. Geographers get to learn data analysis, and to read Robert Macfarlane. They learn geographic information systems. They can turn maps from a two-dimensional representation of a country's physical contours into a tool that illustrates social attributes or attitudes: not just where people live, but how, what they think and how they vote. They learn about the physics of climate change, or the interaction of weather events and flood risk, or the way people's behaviour is influenced by the space around them.

https://www.theguardian.com/commentisfree/2015/aug/13/the-guardian-view-on-geography-its-the-must-have-a-level

2. WHO ARE WE?

# GEOGRAPHY DEGREE PROGRAMMES

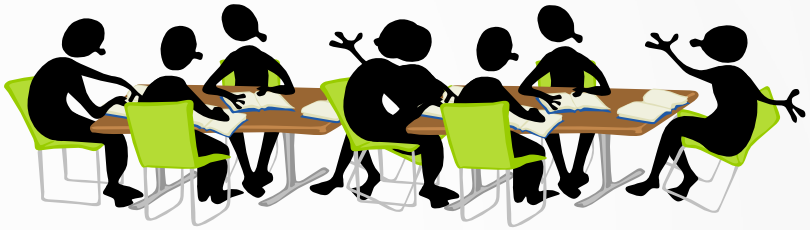
- BSc Study programme: 268 students
- MSc Study programme: 153 students

→ Almost all graduate!

- Students of other programmes, studied with us for a total of 1877 credits

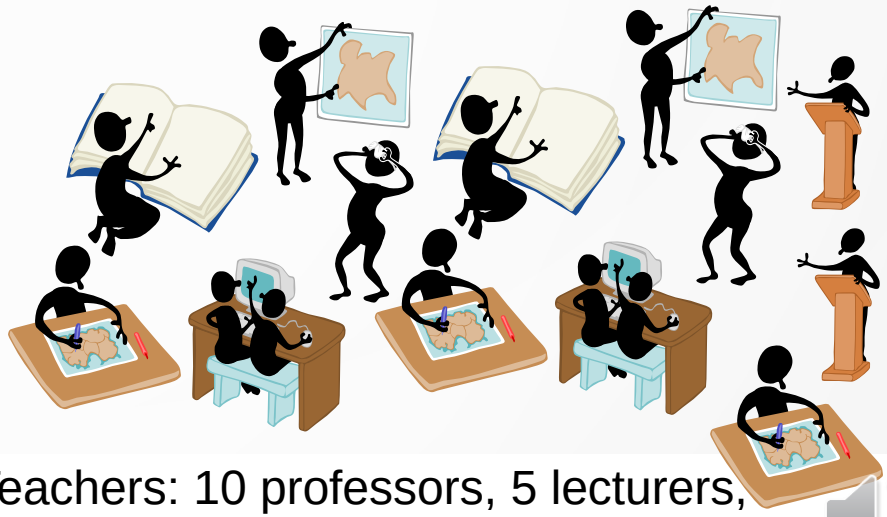
# PEOPLE IN THE GEOGRAPHY DEGREE PROGRAMME

Coordination team



Geography board

Students:
BSc 268
MSc 153



Teachers: 10 professors, 5 lecturers, 2 instructors and many researchers!

3. THE THREE STUDY LINES

UNIVERSITY OF HELSINKI

FLAMMA CITY OF HELSINKI | SUOMI SVENSKA

NEWS STUDYING RESEARCH PROFESSORS TEACHERS AND RESEARCHERS CONTACT ALUMNI STORIES

## HOW TO UNDERSTAND GEOGRAPHICAL DEVELOPMENT AND DIFFERENTIATION OF OUR PLANET?

Geography, University of Helsinki was ranked once again among the top 50 in the world (QS World University Rankings by Subject 2017)! Join the lively group of geographers in Helsinki! Over 50 Master's students begin their studies in geography at the Kumpula campus next autumn, along with 55 new Bachelor's degree students.

**https://www.helsinki.fi/en/programmes/master/geography**

UNIVERSITY OF HELSINKI

FLAMMA CITY OF HELSINKI | SUOMI SVENSKA

NEWS STUDYING RESEARCH PROFESSORS TEACHERS AND RESEARCHERS CONTACT ALUMNI STORIES

**GEOGRAPHY**
Master's programme

GEOGRAPHY / STUDYING /

# THREE STUDY TRACKS

The Master's programme in geography is divided into three study tracks. The study tracks offer students the opportunity to specialise in different areas of geography. The Master's programme contains both general and study track-specific courses.

Teaching within the Master's programme in geography is seamlessly connected with the Master's programme in urban studies and planning (USP), which is jointly implemented with Aalto University.

The study tracks in the Master's programme for geography are:

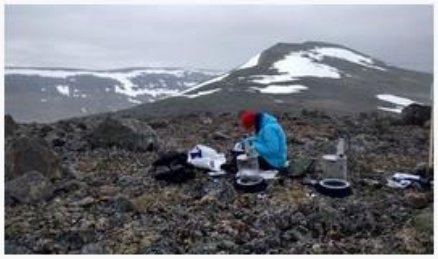
- physical geography
- human & urban geography and spatial planning
- geoinformatics

**Environmentally and societally important geographical questions that benefit from advanced data analytics**

↓ Physical geography
↓ Human & urban geography and spatial planning

↓ Geoinformatics

4. TEACHING BASED ON RESEARCH!



## THE BIOGEOCLIMATE MODELLING LAB

The BioGeoClimate Modelling Lab is focused on the spatial and temporal modelling of Earth systems, particularly patterns and processes...

## AQUATIC COMMUNITY ECOLOGY GROUP

In Aquatic Community Ecology Group we study community ecology, biogeography and macroecology and use unicellular organisms in aquatic...

## TRANSNATIONAL SPACES OF PLANNING AND POLITICS

RELATE, Academy of Finland, Centre of Excellence, research group on changing state spaces 2014-2019. This project is funded by the Academy...

## URBAN GEOGRAPHY AND URBAN ACADEMY

Mari Vaattovaara has lead and been involved in several national and international research projects, which include: Uusi kaupunkiköyhyys ja...

## DIGITAL GEOGRAPHY

The Digital Geography research group uses novel big (and open) data sources and cutting-edge analyses to support sustainable spatial...

## LAND CHANGE STUDIES IN AFRICA

This research group studies land use and land cover changes taking place in sub-Saharan Africa due to agricultural expansion. More...

## TAITA RESEARCH STATION

Taita Research Station led by Professor Petri Pellikka is a multidisciplinary research station in the Taita Hills in southeastern Kenya...

# PHYSICAL GEOGRAPHY AT GEOGRAPHY MASTER'S PROGRAMME

- Deepen the understanding in geographical phenomena in natural world
- Learn key methods in physical geography (five courses, two compulsory)
- Learn to plan and conduct academic research in physical
- Learn to disseminate the results to academic and public audience

# CORE RESEARCH TOPICS IN PHYSICAL GEOGRAPHY AND CORRESPONDING COURSES

- Global change effects on Arctic environment (*seminars, book exams, Arctic environment research*)
- Biogeography and macroecology of aquatic and terrestrial systems (e.g. *Modelling in physical geography, Spatial aquatic research*)
- Species distribution modelling (e.g. *Modelling in physical geography*)
- Big data, GIS and remote sensing in physical geography (*Modelling in physical geography, Spatial terrestrial research, Spatial aquatic research*)
- Physical-chemical quality and ecological status of aquatic systems (*Spatial aquatic research*)

# HUMAN GEOGRAPHY AT THE GEOGRAPHY MASTER'S PROGRAMME

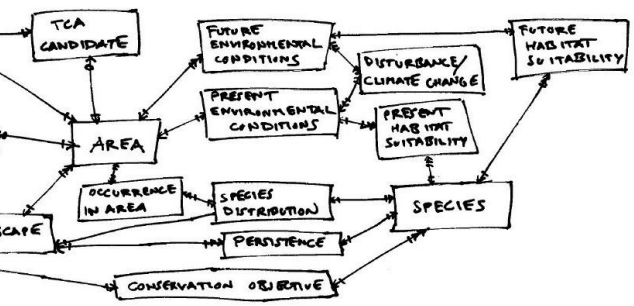
- Examines the spatiality of societal processes that have taken place primarily during the past two hundred years
- Is a social science that both draws on and contributes to social theory (with the aim of ”spatializing” it)
- Deepens your skills in research methods, academic writing and expertise on geography

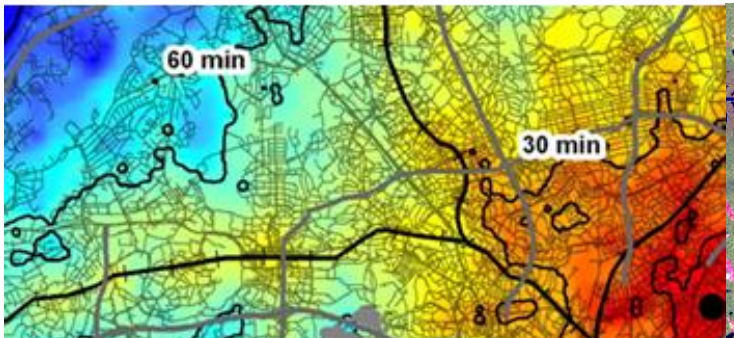
# CORE RESEARCH TOPICS IN HUMAN GEOGRAPHY AND CORRESPONDING COURSES

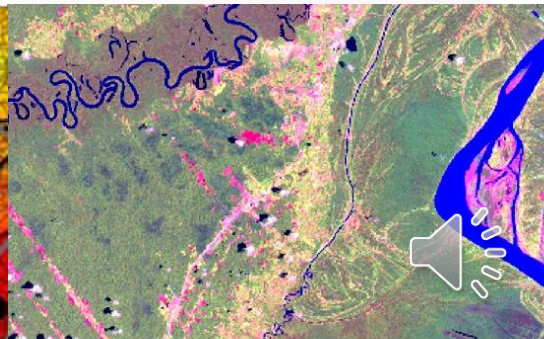
- Urbanization, urban change, segregation and city-regions (*Book club in urban geography, spatial planning and human geography*)
- The spatial transformation of states
- Political economy of knowledge-intensive capitalism
- Politics of spatial planning (*Geographies of European integration and European spatial planning*)
- Geography of education (urban geography) (*Urban dynamics and neighborhood change*)
- Geographies of inequalities (*Geographies of inequalities, Geographies of segregation and educational inequality*)

# GEOINFORMATICS AT GEOGRAPHY MASTER'S PROGRAMME

- Familiarises with the core literature of geoinformatics
- Develops unique methodological skillset from spatial data collection/mining to visualization of the results
- Builds knowledge on spatial analytics in various geographical contexts
- Familiarises with the societal processes around the use of geoinformatics in decision-making

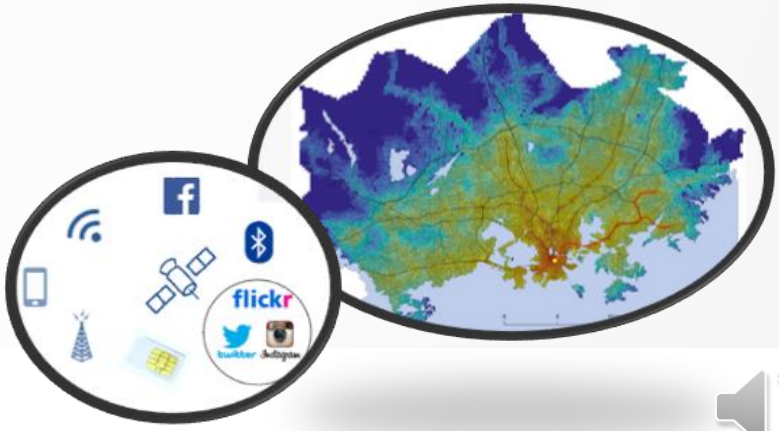


# CORE RESEARCH TOPICS IN GEOINFORMATICS AND CORRESPONDING COURSES

- GIS in urban geography (*Accessibility and mobility, GIS in Society*)
- Conservation geography (*Conservation planning and management, Protected areas in space and time*)
- Spatial Big Data Mining (*Automating GIS-processes 1: Geo-Python and 2: Geography*)
- Remote sensing (*3D-analyses in GIS, Imaging spectroscopy*)

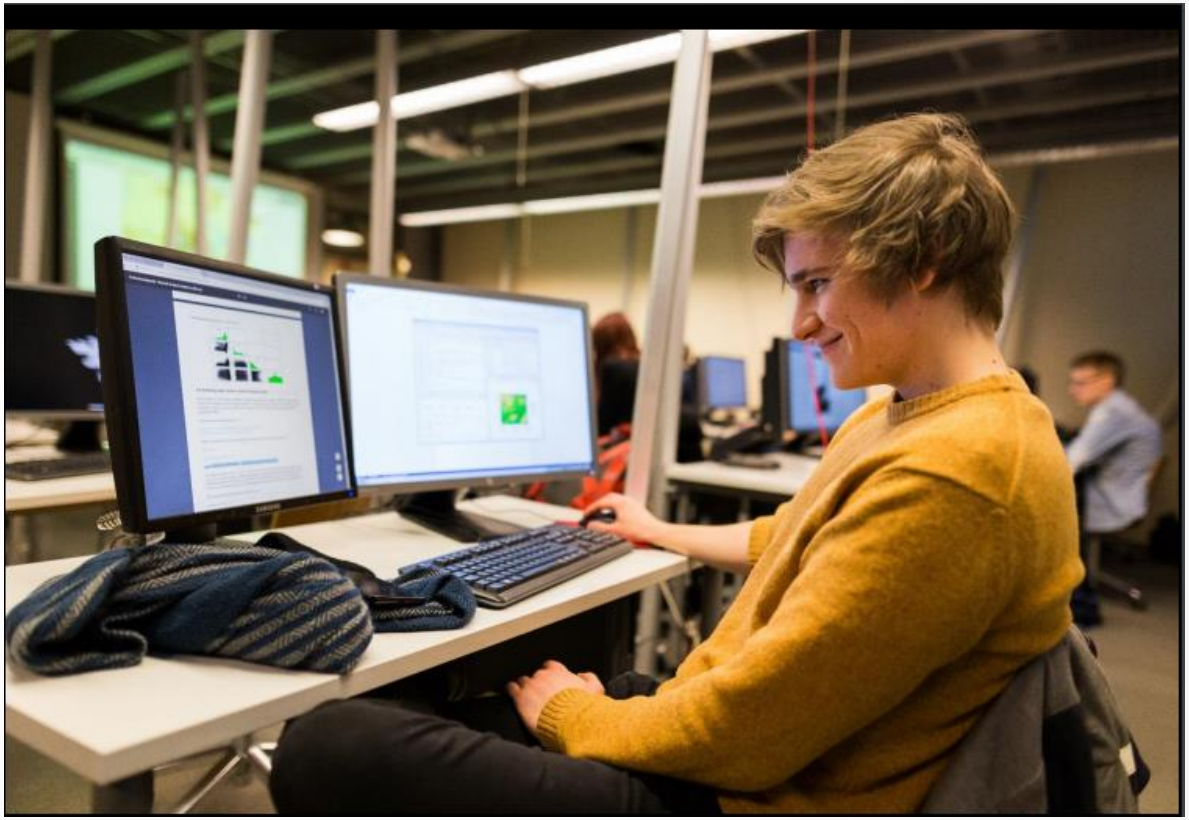


*Kuva 1. Yliopistoissa opetus linkittyy tiiviisti tutkimukseen. Loppuvaiheen opiskelijat oppivat uutta kurssien ohella osallistumalla tutkimushankkeiden toimintaan. Kuva:Arttu Paarlahti*

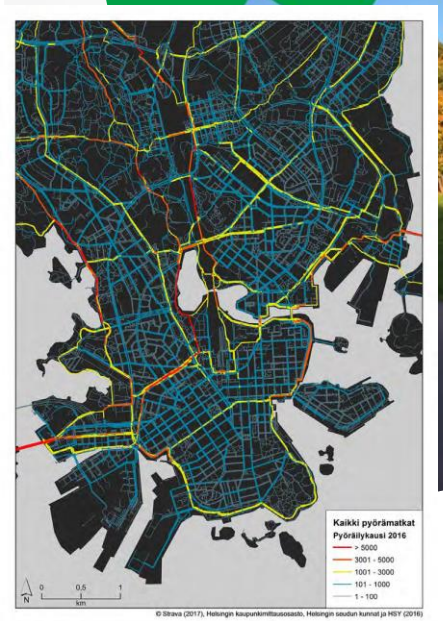
Geography students can choose up to 60 credits from other programs.
Everyone can build their own unique expertise!

**Geography students can choose up to 60 credits from other programs.**

**Everyone can build their own unique expertise!**



6. A LOT OF SOCIETAL RELEVANCE



UUDENMAAN EKOLOGISET VERKOSTOT ZONATION-ANALYYSIEN PERUSTEELLA

Uudenmaan liiton julkaisuja E 194 - 2018

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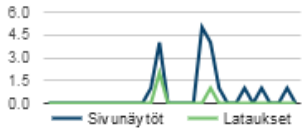
SIVUNÄYTÖT JA LATAUKSET

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(Päivitetään kerran vuorokaudessa.)

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kaikista pääkaupunkiseudun YKR-ruuduista (13 230 kpl)

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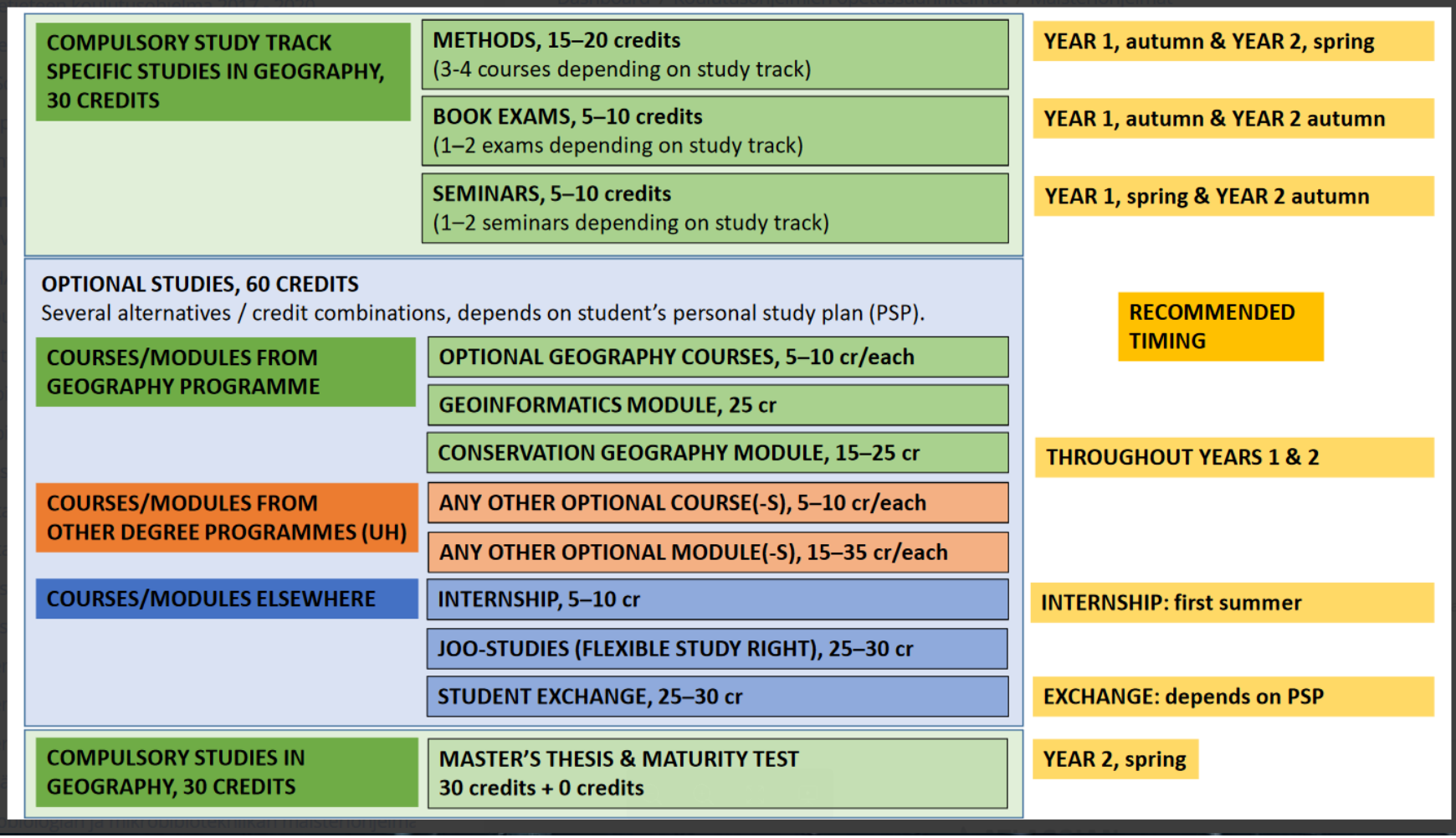

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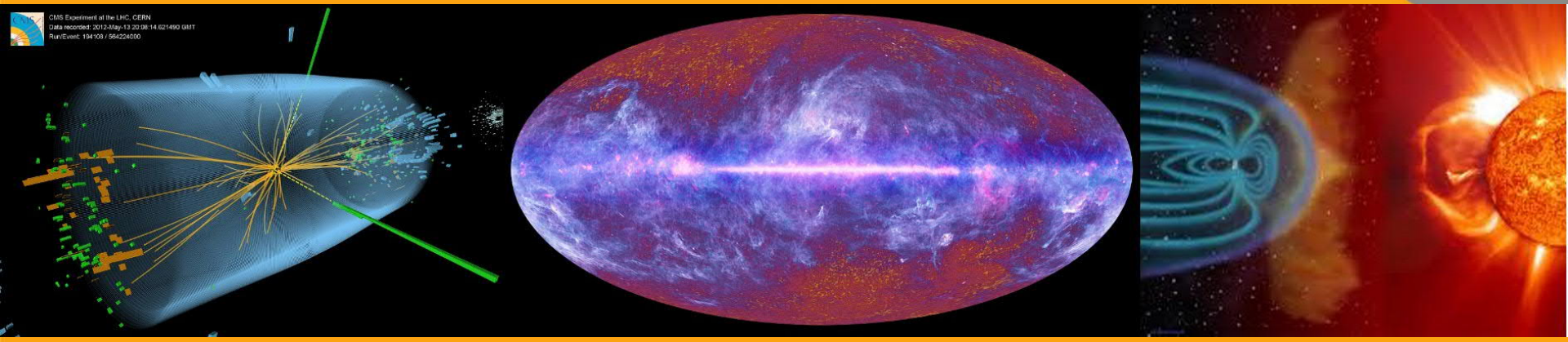
# Master's programme in Particle Physics and Astrophysical Sciences (ParAS)

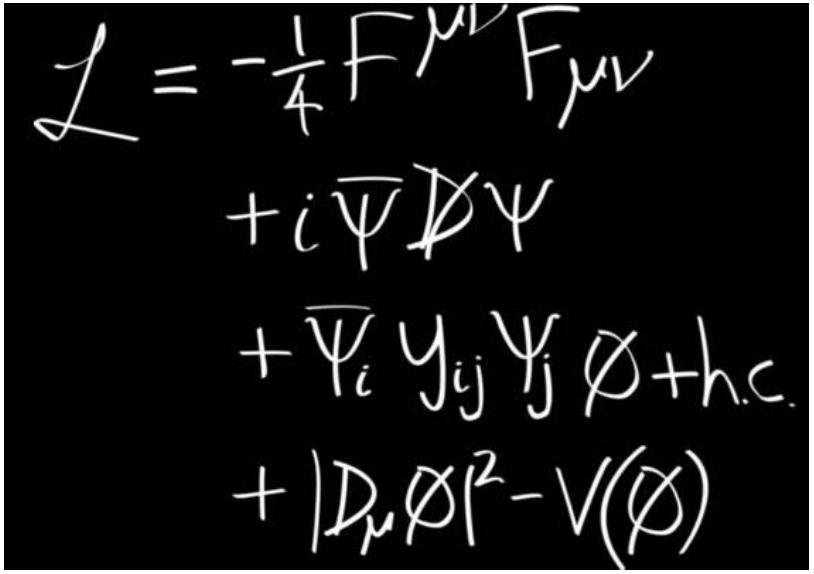
## Presentation of Master programmes 22.3.2021

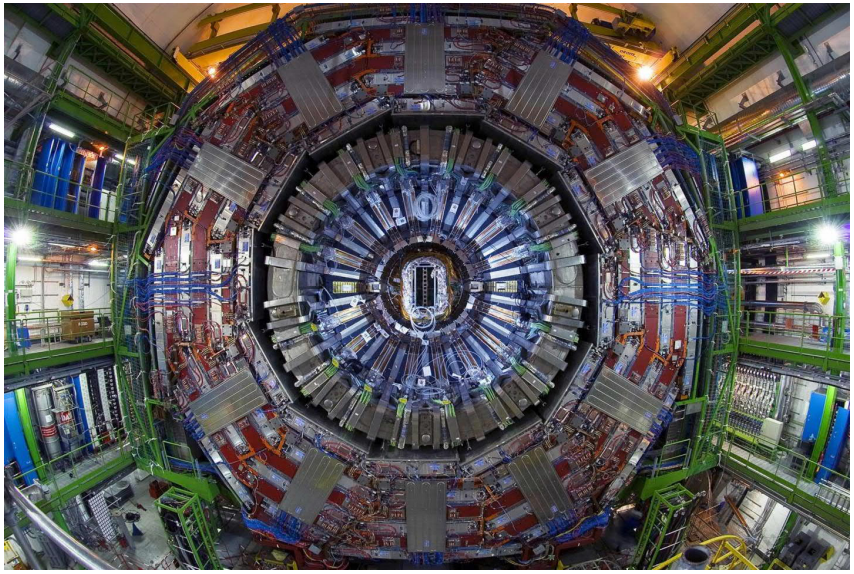


# Research related to ParAS programme

## Theoretical and experimental particle physics

Physics of particle colliders & early universe, quantum field & string theory, particle collider data analysis, particle detector construction



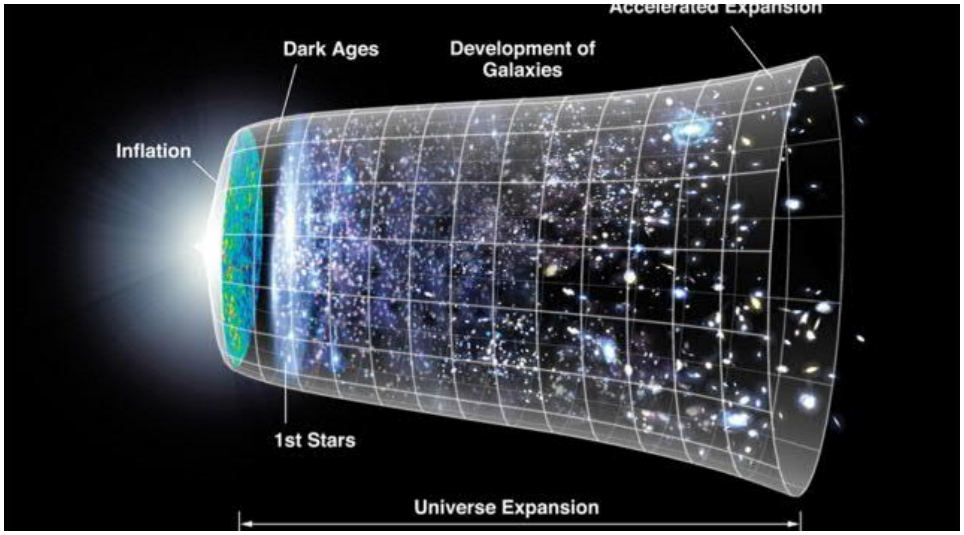



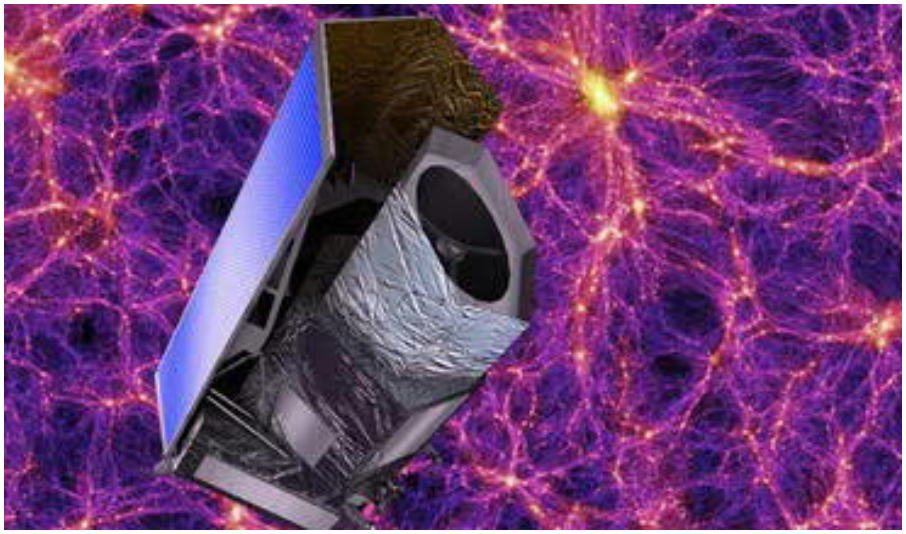
- What are the laws governing the elementary particles ?
- What is the origin of mass ?
- Is there a Theory of Everything, i.e. a theory unifying all fundamental forces & describing all elementary particles ?

# Research related to ParAS programme

## Theoretical and observational cosmology

Physics of the very early universe, the origin of matter, dark energy, dark matter & the structure of the universe.



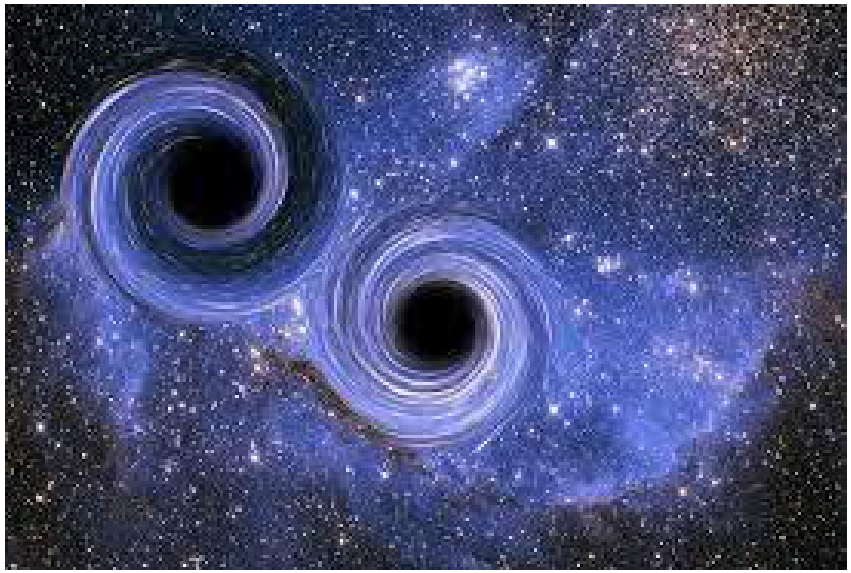



- What are the laws governing the very early universe ?
- What are the origins of dark energy & dark matter ?
- What are the mechanisms behind an expanding universe ?

# Research related to ParAS programme

## Theoretical and observational astronomy

Gravitational waves, physics of black holes, galaxy formation & evolution, star formation, planetary science



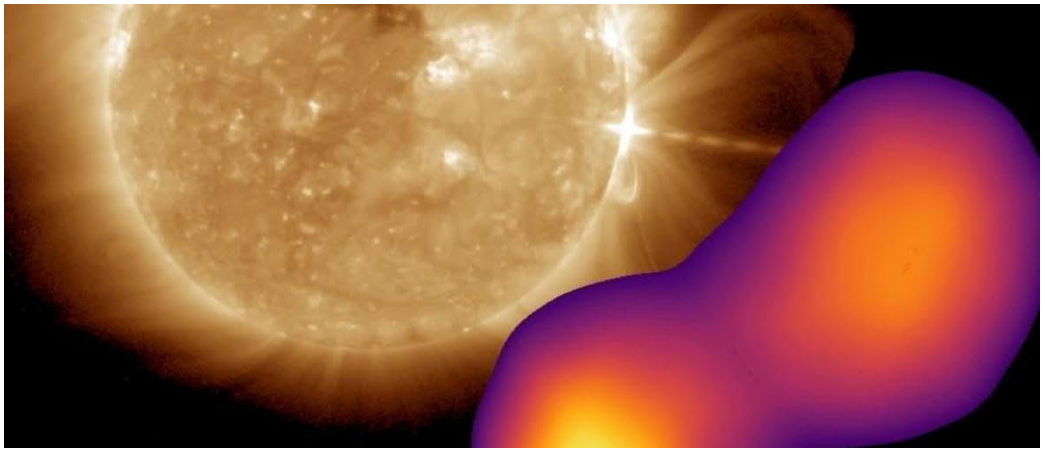
- What are the laws governing black holes ?
- What are the mechanisms of galaxy & star formation ?
- How can a potential asteroid impacting earth be spotted sufficiently early to be able to counteract ?

# Research related to ParAS programme

## Space physics

### Space weather & sustainable space

- How can space weather detrimental to technical systems on ground & in space be better predicted ?
- How can orbit safety of satellites & space missions be maintained considering the increased amount of space debris ?
- What is the most efficient way of satellite & space mission propulsion ?



# ParAS programme

Research done in close collaboration with national (e.g. Helsinki Institute of Physics (HIP), Finnish meteorological institute (FMI)) & international organisations (e.g. CERN, ESA, ESO,…) ⇒ research based/oriented training & teaching

Multilingual programme; teaching language English

2 study track:

- Particle physics and cosmology
  - Theoretical and experimental particle physics
  - Theoretical and observational cosmology
- Astrophysical sciences
  - Theoretical and observational astronomy
  - Space physics

# ParAs degree structure

120 credits consisting of
- 90 credits advanced studies (incl. MSc thesis 30 credits)
- 30 credits other studies (ParAs or other programmes)

**Study line for Particle Physics and Cosmology**

- MSc thesis 30 ECTS
- ParAs seminars 5 ECTS
- PP & C Core package 5-10 ECTS
- Particle Physics 5-35 ECTS
- Quantum physics 5-20 ECTS
- Cosmology 5-55 ECTS
- PP experimental methods 5-40 ECTS
- Instrumentation 5-20 ECTS
- PP specialization 5-15 ECTS
- Other studies (ParAs/other) 30 ECTS

**Study line for Astrophysical Sciences**

- MSc thesis 30 ECTS
- ParAs seminars 5 ECTS
- AS Core package 15 ECTS
- Observation astronomy package 5-40 ECTS
- Theoretical astronomy package 5-45 ECTS
- Space physics package 5-40 ECTS
- Other studies (ParAs or other programme's) 30 ECTS

Mandatory course packages:

Optional course packages:

PP = Particle Physics, C = Cosmology, AS = Astrophysical Sciences

# Courses

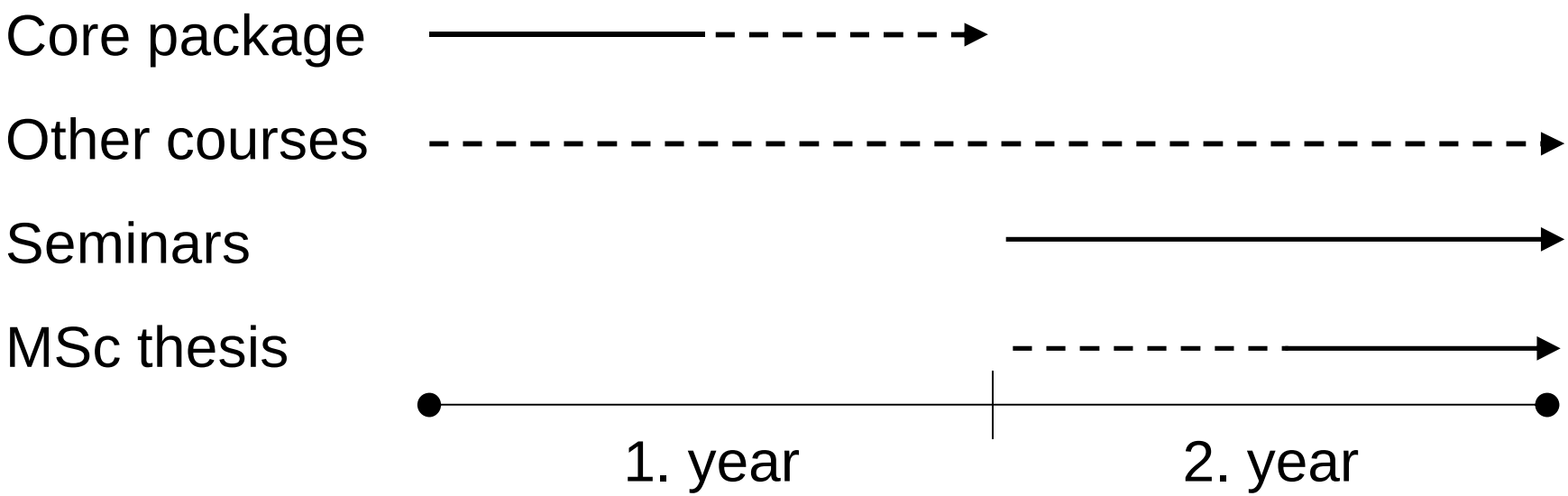
## (mandatory courses below lectured each academic year, others usually every second academic year)

- MSc thesis (30 cr)
- ParAS seminars (5 cr)
- Particle physics & cosmology study track (core package):
  - FYS2081 Cosmology I (5 cr)
  - PAP326 Cosmology II (5 cr)

  **or**
  - PAP332 Introduction to Particle Physics I (5 cr)
  - PAP325 Introduction to Particle Physics II (5 cr)
- Astrophysical Sciences study track (core package):
  - PAP302 Open problems in modern astrophysics (5 cr)
  - PAP303 Statistical Inverse Methods (5 cr)
  - PAP304 Plasma Physics (5 cr)

Same courses serve as introductions to particle physics, cosmology, astronomy (”Open problems in modern astrophysics”) & space physics (”Plasma Physics”); can either be taken during BSc or at start of MSc.

# Timing of studies




**Prerequisites:**

- 60 credits basic physics and mathematical methods in physics
- 15 credits quantum physics/modern physics/basic astronomy

❑ All choosing study track in physics, theoretical physics or astronomy in Bachelor's programme of Physical sciences or study track in physics in Bachelor's programme in Science fulfill the prerequisites.

# ParAS career opportunities

Students learn during the studies strong analytical & computational skills with capability of e.g. analysis of very large data sets or modelling complex systems

Possible career opportunities include:

- Research & teaching positions in Finnish universities & research institutes (HIP, FMI, Finnish Geodetic Institute (FGI)…) or abroad e.g. CERN, ESA, ESO or NASA
- Administrative positions, e.g. Academy of Finland, STUK (radiation and nuclear safety authority) or patent offices
- Data analysis in e.g. industry, media companies (Sanoma), game companies (Supercell), financing (OP Bank)
- Industrial research, development or consulting at e.g. Nokia, Apple, Ericsson, Planmeca, Vaisala, Space systems, Reaktor and Goldman Sachs.

# Contacts for ParAS programme

- Director: Dr. **Anca Tureanu** – theoretical particle physics
- Deputy director: Prof. **Peter Johansson** – astronomy
- Education coordinator: Ms. **Tiina Hasari**

- Steering board:
- Lecturer **Mika Juvela** – astronomy
- Assist. prof. **Adnane Osmane**– space physics
- Lab. Eng. **Eija Tuominen** – particle physics instrumentation
- Assoc. prof. **Aleksi Vuorinen** – theoretical particle physics & cosmology
- Prof. **Kenneth Österberg** – experimental particle physics

contact by email: firstname.surname@helsinki.fi

Link:

- go to https://guide.student.helsinki.fi/en → choose ”Master's Programme in Particle Physics and Astrophysical Sciences” & then e.g. ”Plan your studies” → ”Structure and scope of the degree programme”

# Web pages of ParAS

Master's programme in Particle Physics and Astrophysical Sciences
General page on the university site, mostly for the use of international applicants, but contains useful information for all students in a rather compact form

Preliminary syllabus for the academic year 2020-2021
(will be soon updated at the same place for the academic year 2021-2022)

WebOodi course catalogue for 2020-2021
This will disappear in the end of May, when WebOodi will be completely covered by Sisu.

Wiki pages of ParAS courses and degree structure

**Soon to come**: Wiki pages of the programme, which will be maintained and updated in a timely fashion, with information relevant for the students already enrolled in the programme.