MASTER'S PROGRAMME IN LIFE SCIENCE INFORMATICS (LSI)

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LIFE SCIENCE INFORMATICS (LSI)

Life Sciences is one of the strategic research fields at the University of Helsinki. **The multidisciplinary LSI programme integrates research excellence in the Helsinki Institute of Life Sciences (HiLIFE)**. As a student, you will gain access to active research communities on three campuses: Kumpula, Viikki, and Meilahti.

The unique combination of study opportunities tailored from the offering of the three campuses provides an attractive educational profile in life sciences.

City Centre Campus

The multidisciplinary City Centre Campus in the very heart of Helsinki is the largest campus of the University of Helsinki. The City Centre...

Kumpula Campus

The Kumpula Campus, dedicated to research and teaching in the exact natural sciences, is perched on a verdant hill only four kilometres...

Viikki Campus

The Viikki Campus is a hub of teaching and research in the biosciences, agriculture and forestry, pharmacy, and veterinary medicine.

Meilahti Campus

Meilahti Campus is a campus where top-notch medical research, education and care meet.

WHAT ARE LIFE SCIENCES? WHAT HAS INFORMATICS TO DO WITH THEM?

Life sciences is a general term for **fields of science studying life and organisms**

- Application areas of life sciences range from, e.g., healthcare and medicine to agriculture and food-production

- One of the strategic fields of University of Helsinki

Life sciences and their application areas are producing enormous amounts of data and theoretical questions that cannot be analyzed without tailored methods from mathematics, statistics and computer sciences – **Life science informatics develops and studies methods to answer these questions**
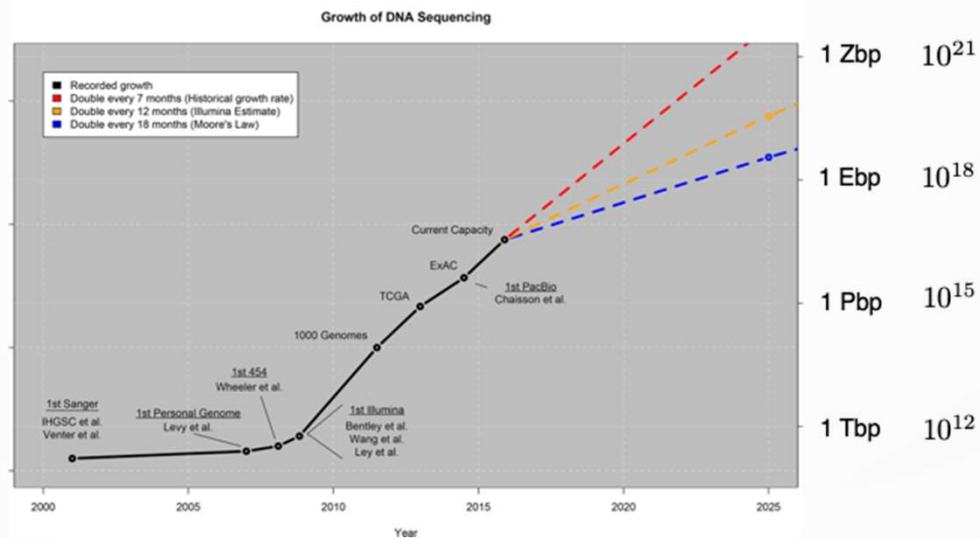
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HELSINGFORS UNIVERSITET
UNIVERSITY OF HELSINKI

Matemaattis-luonnontieteellinen tiedekunta

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WHAT ARE LIFE SCIENCES? WHAT HAS INFORMATICS TO DO WITH THEM?

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WHY LIFE SCIENCE INFORMATICS?

As a graduate of the Life Science Informatics programme you will:

- Have **first class knowledge and capabilities for a career in life science research and in expert duties** in the public and private sectors

- Have understanding of the regulatory and ethical aspects of scientific research

- Have excellent communication and interpersonal skills for employment in an international and interdisciplinary professional setting

- **Understand the principles of mathematical modelling, computational, probabilistic and statistical analysis of biological data, and be an expert in your specialisation area of the LSI programme**

- Understand the logical reasoning behind experimental sciences and be able to critically assess research-based information

- Have mastered scientific research, making systematic use of investigation or experimentation to discover new knowledge

- **Have good opportunities to continue your studies for a doctoral degree**

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PROGRAMME STRUCTURE

Life Science Informatics Master´s programme 120 cr

Personal study plan

PSP / HOPS

Contact study track director when you start your studies.

Advanced studies 85 – 120 cr

Introductory courses from study tracks, at least 15 cr

Study track specific courses 35 – 75 cr

- Study tracks give a set of courses.
- In addition:
  - courses from other study tracks
  - advanced courses from other programmes.
- The content of studies will be agreed in personal study plans (PSP / HOPS).

Master´s thesis 30 cr
Master´s thesis seminar 5 cr

Other studies 0 – 35 cr

- Courses and/or modules from other disciplines (other programmes). The courses and modules can be bachelor level ones.
- Bachelor´s level courses in mathematics, statistics, computer science as agreed in personal study plan. Requirements of these courses depend on the content of BSc-degree studies.

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STUDY TRACKS

We have 4 study tracks

- Bioinformatics and systems medicine
- Biomathematics
- Biostatistics
- Ecological informatics

To be introduced in more detail next

https://www.helsinki.fi/en/programmes/master/life-science-informatics/studying/programme-structure

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BIOINFORMATICS AND SYSTEMS MEDICINE

Life Science Informatics Master's Programme

Bioinformatics and Systems Medicine study track

- Courses from three campuses:
  - Kumpula: Algorithmic Bioinformatics
  - Viikki: Applied Bioinformatics
  - Meilahti: Systems Biology and Medicine
- Any combination of these courses is possible, but you can focus more on one of these based on your interest towards a thesis topic.

Algorithmic Bioinformatics

- Provides students:
  - Skills to formulate biological problems as discrete optimization problems and solve them using tailored algorithm techniques.
  - Basic understanding of cell biology and measurement techniques (e.g. sequencing).
  - Understanding on how the widely used bioinformatics software tools work.
- Focus in methods:
  - Take also general algorithms courses / seminars from CS Master's Programme to obtain a more general toolbox.
  - Take molecular biology courses to deepen the understanding of cell biology.

Applied Bioinformatics

- Provides students:
    - Expertise on how to turn biological questions into appropriate challenges for computational data analysis.
    - Hands on expertise how to apply innovative computational approaches used in an increasingly data-dense environment of biology research.
- Focus in application:
    - Take also general data science courses / seminars from CS Master's Programme to obtain a more general method toolbox.
    - Take also molecular evolution, biology, and biomedical courses to deepen the understanding of biology and biodata.

Systems Biology and Medicine

- Provides students:
    - Ability to execute standard data analyses and interpret results using clinical and biomedical data from patients or healthy individuals.
    - Basic understanding of cell biology and medicine.
    - Skills to develop computational methods that applicable to (human) molecular and clinical data.
- Focus in application:
    - Strong methodological expertise is important.
        - Take also other LSI courses.
    - Biology/medicine understanding important.
        - Some courses should be taken from TRANSMED.

BIOMATHEMATICS

Life Science Informatics Master's Programme

BIOMATHEMATICS: The Mathematics of Life
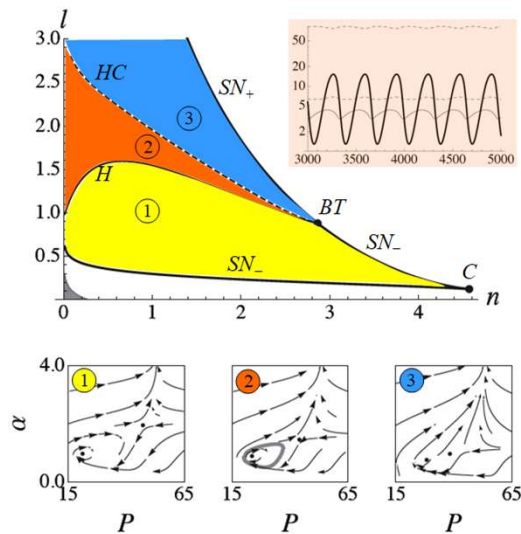
The mathematician owns a wonderful tool created by the efforts of many ingenious people, accumulated through the centuries.

He has the key that can open a way to the many mysteries of the Universe and obtain, by a few symbols, a synthesis that covers and connects many and diverse results of different sciences." — Vito Volterra —

MODELS: Construction and analysis

There is a model behind every experiment; data make sense in the light of models

- derive models from first principles (rather than ad hoc formulas)
- derive population-level phenomena from the behaviour of individuals

- creative insight and understanding of processes
- a variety of mathematical approaches
- at the heart of modern Bayesian statistics
- transferable skills for modelling real-life phenomena

MATH ECOLOGY: A unique MSc program

- Mathematical modelling
- Introduction to mathematical biology
- Mathematics of infectious diseases
- Evolution and the theory of games
- Adaptive dynamics
- Stochastic population models
- Spatial models in ecology and evolution

    + courses by guest lecturers

RESEARCH-BASED with publishable MSc theses

Examples from our research interests:
- evolution of hosts and pathogens
- evolution in predator-prey systems
- evolution in fragmented populations
- evolution in stochastic environments
- the origin of species
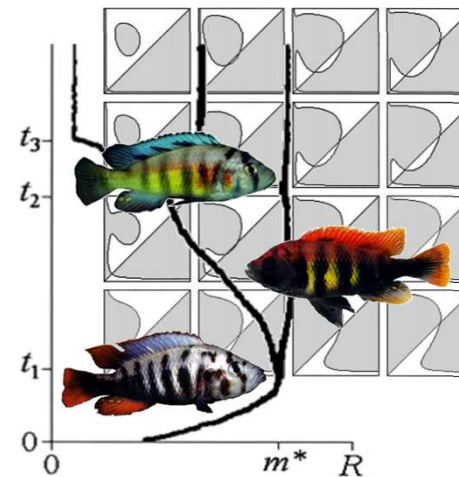
Recent and ongoing MSc theses:
- joint evolution of dispersal and connectivity (J. theor. Biol. 2017, Evolution 2019)
- evolutionary suicide (Bull. Math. Biol. 2019)
- vaccination schedules to counter waning immunity
- spreading disease and awareness

RESEARCH-BASED with publishable MSc theses

Examples from our research interests:
- evolution of hosts and pathogens
- evolution in predator-prey systems
- evolution in fragmented populations
- the origin of species

Possible MSc theses:
- see ideas in the Dept Mathematics collection of MSc thesis topics:
  https://www.overleaf.com/read/nqkvpncjhgpz
  (scroll down to Mathematical modelling and mathematical biology)
- most topics chosen by discussing ideas in person: contact
  Eva Kisdi or Stefan Geritz (firstname.lastname@helsinki.fi)
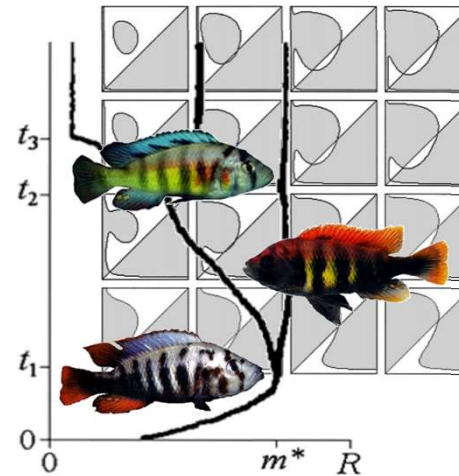
BIOSTATISTICS

Life Science Informatics Master's Programme

BIOSTATS, WHAT AND WHERE?

Public Health ("*Statistical Epidemiology*", "*Event-history*")

THL (Institute for Health and Welfare)

Statistical Genetics ("*Genome-wide association studies, population genetics*")

FIMM (Institute for Molecular Medicine Finland)

Statistics in medicine

Faculty of Medicine, pharma companies

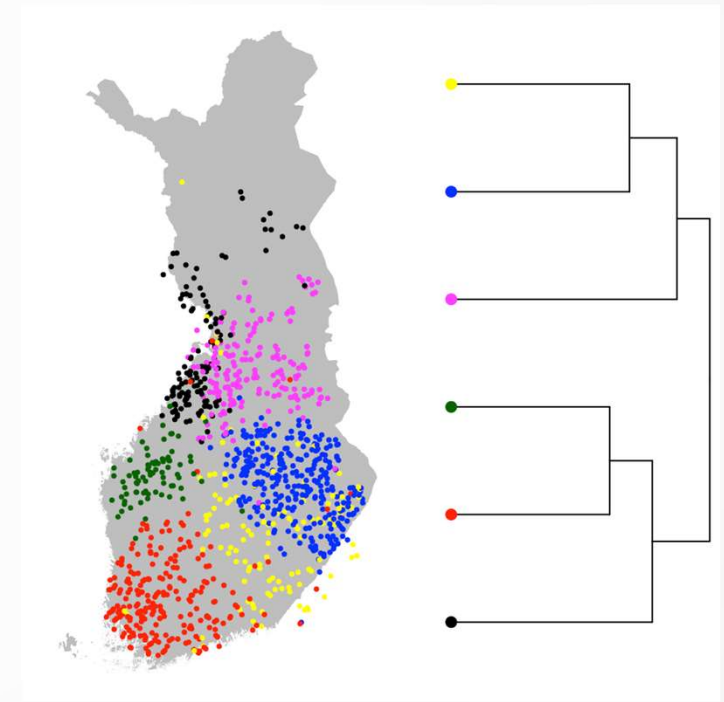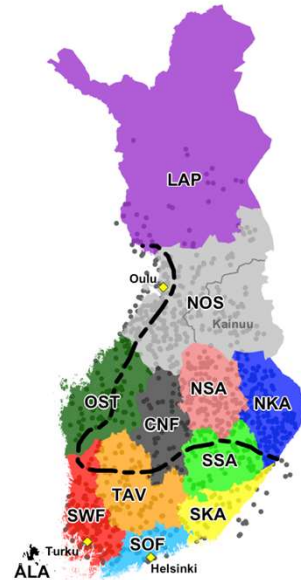Omics ("*High dimensional statistics*")

Research in life sciences, companies

GENETICS OF MIGRAINE

- Statistical problem: Is genetic variation at a particular position associated with disease, here migraine
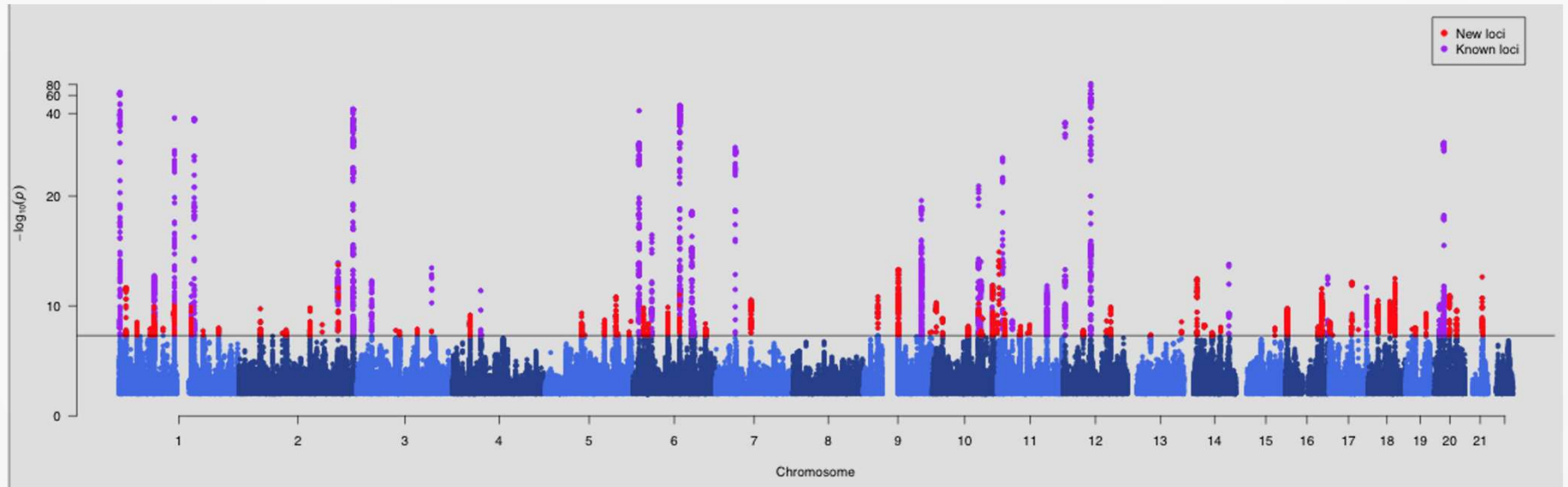
100,000 migraineurs vs. 750,000 controls analyzed @ FIMM

POPULATION GENETICS (IN FINLAND)
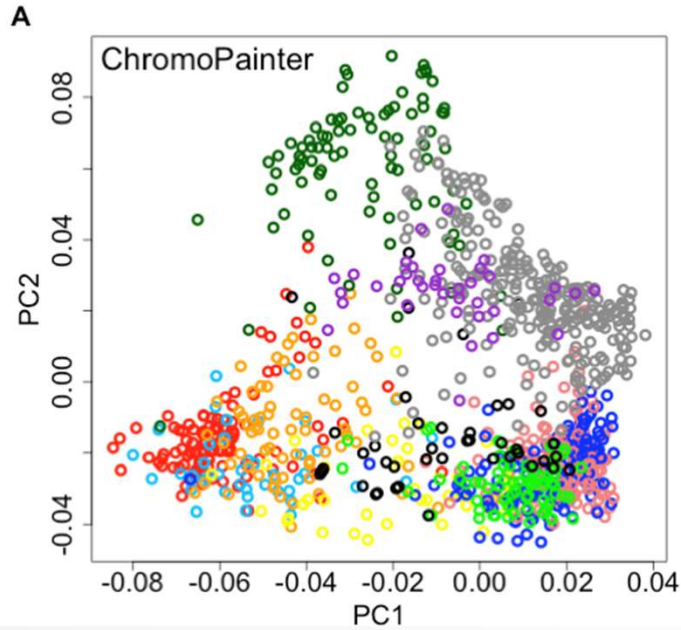
BIOSTATISTICS SUPERVISORS

Matti Pirinen (matti.pirinen@helsinki.fi)

Kumpula:
Maths & Stats

Meilahti:
Faculty of Medicine
Institute for Molecular Medicine Finland

Areas: Genetics, high-dimensional stats

Sangita Kulathinal
(sangita.kulathinal@helsinki.fi)

Kumpula:
Maths & Stats

THL (Institute for Health and Welfare)

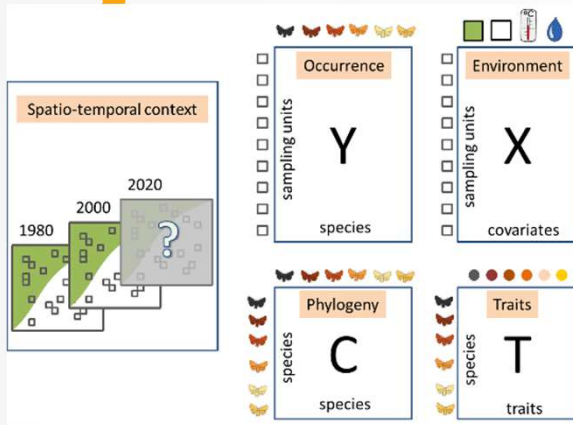Areas: Public health, event histories
high-dimensional stats

ECOLOGICAL INFORMATICS

Life Science Informatics Master's Programme

PROGRAM CONTENT

Studies include for example: Modelling ecology and evolution, Bayesian and spatial statistics, experimental and survey design methods, Project work, …

Ecology studies the distribution and abundance of species, and their interactions with other species and the environment.

Evolutionary biology studies processes supporting biodiversity on different levels from genes to populations and ecosystems.

These sciences have a key role in responding to global environmental challenges.

Eco-evolutionary informatics specialization area provides tools for **mathematical and statistical modelling of ecological and evolutionary processes**. These tools, together with computer science and bioinformatics have an important role in research and teaching.

EXAMPLES OF FUTURE PROSPECTS

PhD studies in UH Doctoral Programmes in:

- Integrative Life Sciences

- Mathematics and Statistics

- Wildlife Biology Research

- Interdisciplinary Environmental Sciences

Or abroad

- Eco-evolutionary informatics is a unique education giving good background for PhD in statistical ecology or related fields

Expert duties in:

- Natural resources assessment and management

- Environmental analysis and management

- environmental and ecological risk analyst

Examples of potential employees:

- Luke, Syke, forest and agricultural sector, consultancy, industry,…

RESPONSIBLE TEACHERS

Jarno Vanhatalo
Associate Professor of statistics,
- Department of Mathematics and Statistics, Faculty of Science
- Organismal and Evolutionary Biology Research Program, Faculty of Biological and Environmental Sciences
- jarno.vanhatalo@helsinki.fi

Indrė Žliobaitė
Associate Professor of life science informatics
- Department of Computer Science,
- Faculty of Science
- indre.zliobaite@helsinki.fi

STUDY TRACK CONTACT PERSONS

biomathematics

Stefan Geritz
- University researcher, Department of Mathematics and Statistics, Kumpula

Eva Kisdi
- University researcher, Department of Mathematics and Statistics, Kumpula

systems medicine

Sampsa Hautaniemi
Professor,
- Research program in systems oncology (ONCOYS), Meilahti

algorithmic bioinformatics

Alexandru Tomescu
- Associate Professor, Department of Computer Science, Kumpula

applied bioinformatics

Ville Mustonen
Professor,
- Organismal and Evolutionary Biology Research Programme, Viikki
- Department of Computer Science, Kumpula
- Institute of Biotechnology
- Helsinki Institute for Information Technology

biostatistics

Matti Pirinen
- Associate Professor, Department of Mathematics and Statistics, Kumpula
- Institute of Molecular Medicine, Meilahti

Eco-evolutionary informatics

Jarno Vanhatalo
Assistant Professor,
- Department of Mathematics and Statistics, Kumpula
- Organismal and Evolutionary Biology Research Program, Viikki

Indrė Žliobaitė
Assisstant Professor
- Department of Computer Science, Kumpula

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GOT INTERESTED IN LSI?

To get more information of the program

- Visit https://www2.helsinki.fi/en/admissions/degree-programmes/life-science-informatics-masters-programme

- For general questions that are not answered by the above website contact:
  - krista.iltanen@helsinki.fi
  - jarno.vanhatalo@helsinki.fi

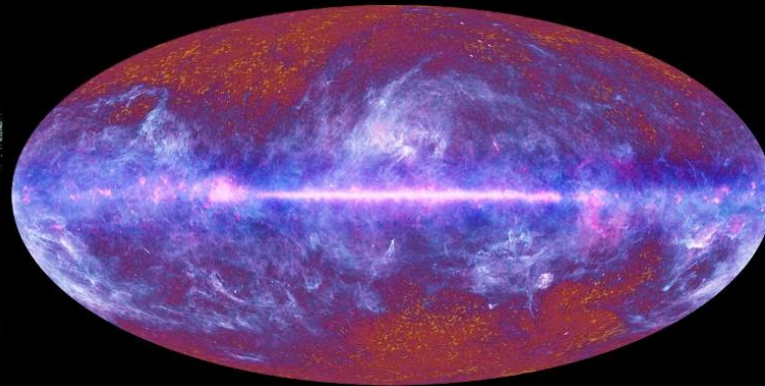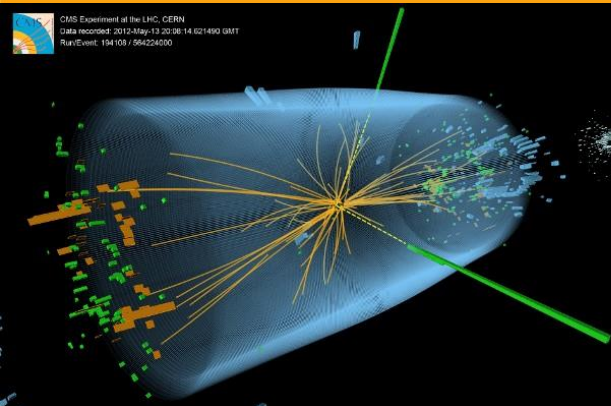- You can ask specific questions concerning study tracks from the study track contact persons.

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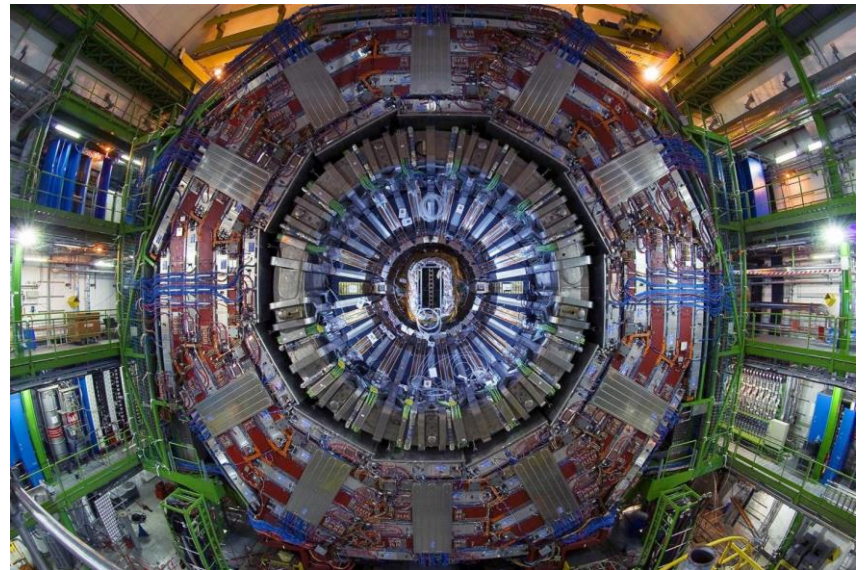
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Research related to ParAS programme

Theoretical and experimental particle physics

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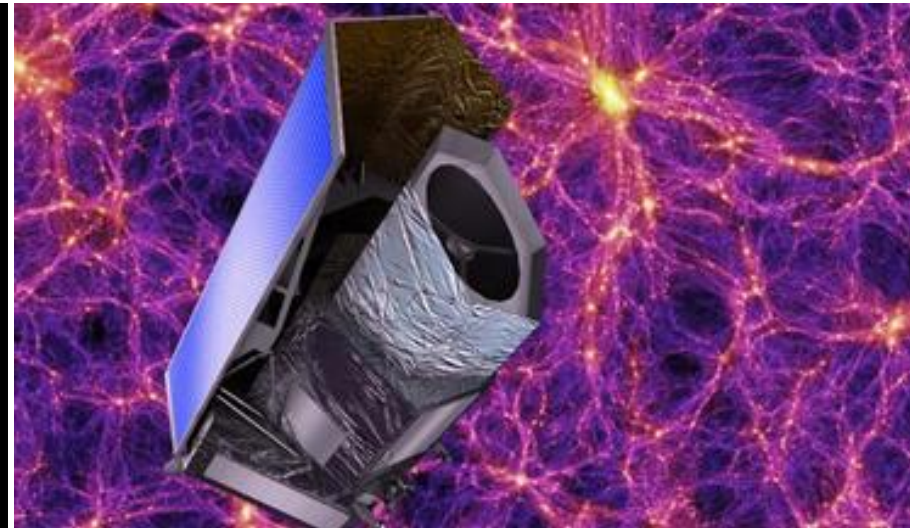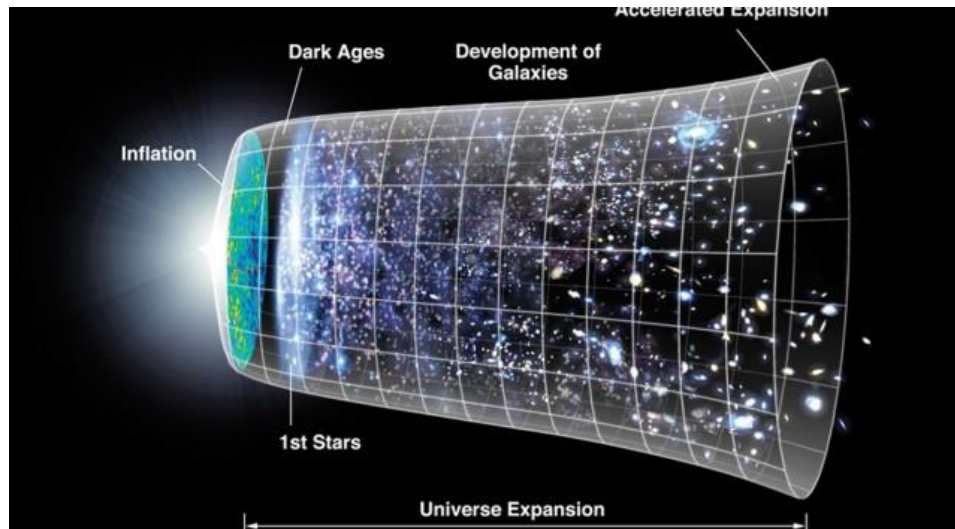

❑ What are the laws governing the elementary particles ?

❑ 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 ?
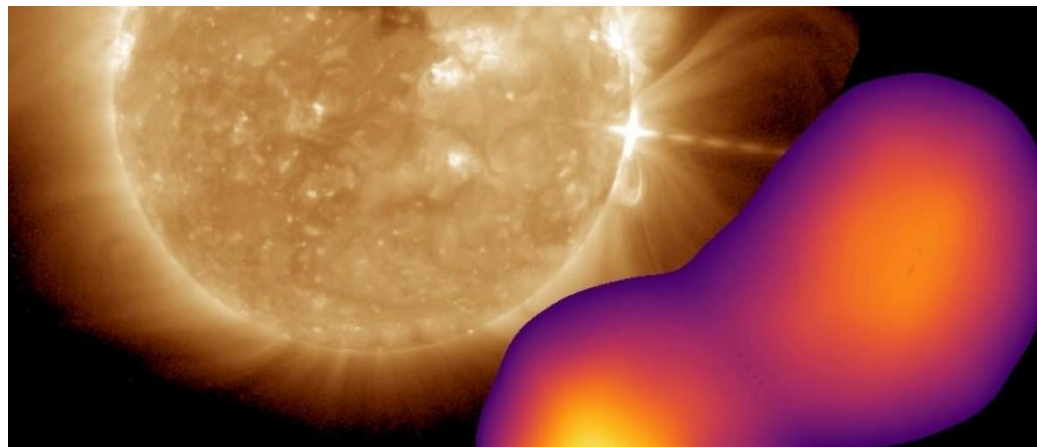
Research related to ParAS programme

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,…) $\Rightarrow$ research based/oriented training & teaching

Multilingual programme; teaching language English
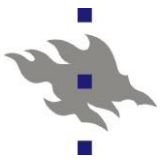
2 study track:

❑ 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 |
| PP & C Core package 5-10 ECTS |
| ParAs seminars 5 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 |

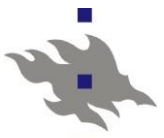| Observation astronomy package 5-40 ECTS | Theoretical astronomy package 5-45 ECTS |
| Space physics package 5-40 ECTS | Other studies (ParAs or other programme's) 30 ECTS |

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

Core package

Other courses

Seminars

MSc thesis

1. year   2. year
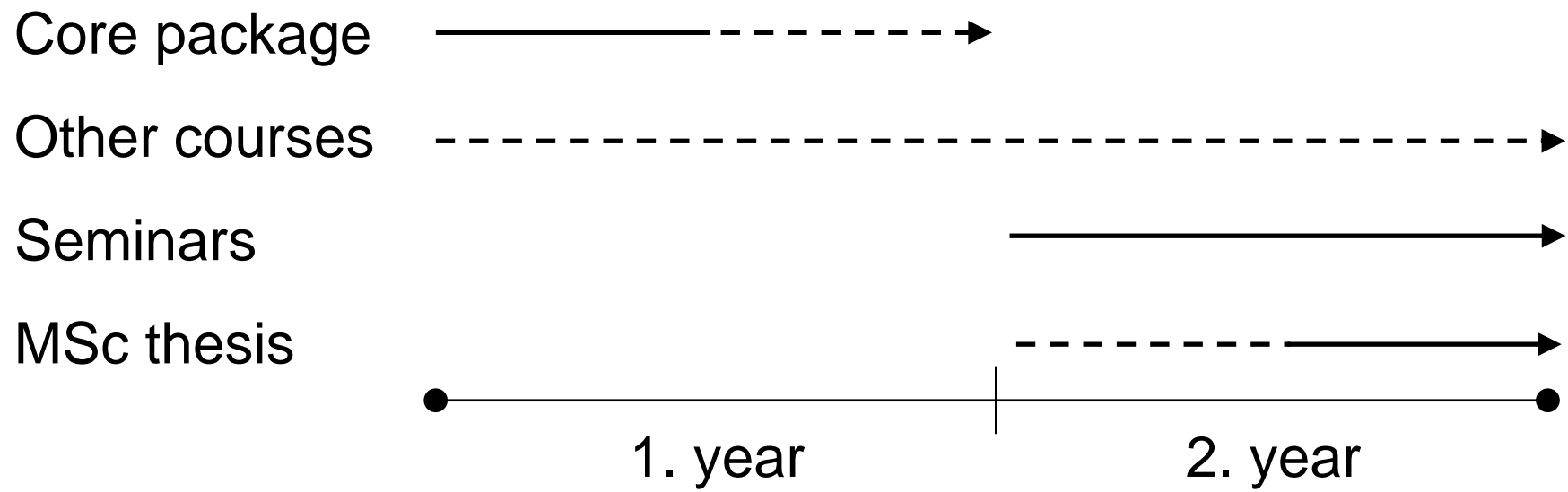
Prerequisites:
- 60 credits basic physics and mathematical methods in physics
- 15 credits quantum physics/modern physics/basic astronomy

❑ 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
- Lecturer **Erik Brücken** – particle physics instrumentation
- 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

Moodle page of ParAs

PARAS course catalogue.pdf

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 2022-2023