# Introduction to Space

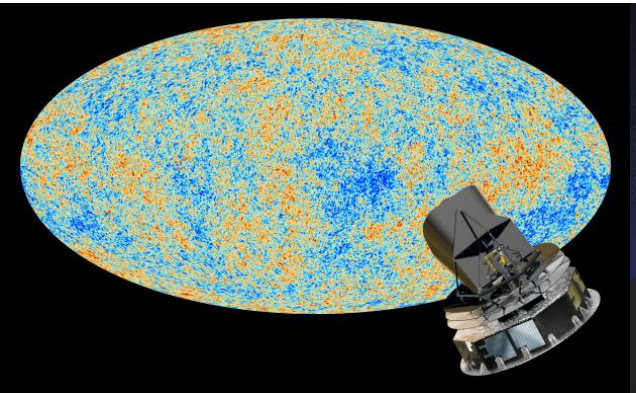
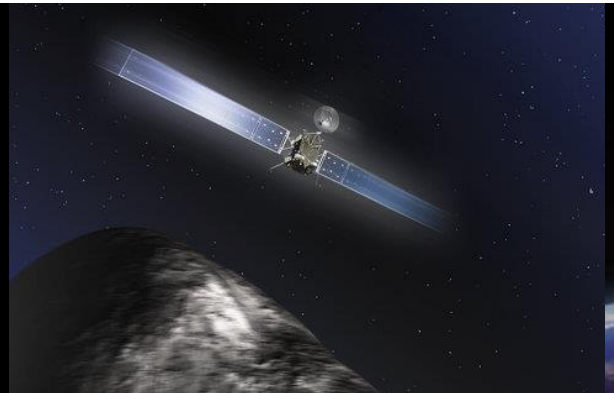
## ELEC-E4210 (5 cr)

ESA/Hubble

# Today

- Course introduction and practicalities. (AL)
- Astronomy / space research activites in Finland and in Aalto.
- Content and dimensions of the Universe.
- Short introduction to space plasma physics. (EK)

ESA


# Teachers

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+course assistants





# Teaching methods & materials

- Many topics, many methods, many materials.
- Teaching methods chosen and applied by each teacher and topic.

- This course gives you the necessary background for… space physics … orbits & celestial mechanics … coordinate systems … emission mechanisms … basic astronomy …

  ….so there is no book to cover this all …

  – Lecture materials in MyCourses, additional reading, links etc.

# Course chat for students

- Join Telegram group at

  https://t.me/joinchat/wx0uowbhChg4N2Zk

- No teachers, this is for students only! Questions to teachers should go via email or general discussion in MyCourses.

# Feedback is welcome

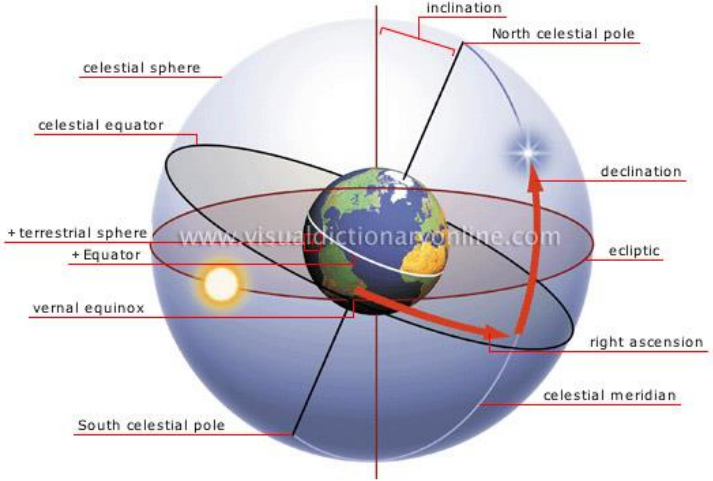
- During and after the course:
  - E-mail
  - MyCourses
  - Talk to us
  - Take the course survey
- Your chance to make this a good course!

# Space science and technology courses

- ELEC-E4220 Space instrumentation
- ELEC-E4230 Microwave Earth Observation instrumentation
- ELEC-E4240 Satellite systems
- ELEC-E4520 Space physics
- ELEC-E4530 Radio astronomy
- ELEC-E4540 Space Climate
- ELEC-E4920 Space technology project (5 – 10 cr)
- ELEC-E4930 Special assignments (5 – 10 cr)

# ”Basics of space”

- Contents of the Universe and the solar system
- Space environment
- Space exploration
- Tools for understanding space
  - Celestial coordinate systems
  - Measurement of time
  - Celestial mechanics, orbits
  - Basics of emission mechanisms, plasma physics and astronomy




Merriam-Webster dictionary

# Learning outcomes

- After the course the student has the basic knowledge of astronomy, space physics and space technology that are needed for further studies.
- The student knows the structure and central physical properties of the universe and the solar system, and the objects contained in them.
- She/he identifies the basic concepts and tools of astronomy and space physics, and is able to solve simple problems related to them.
- The student can list what kind of observations can be made of astronomical and solar system phenomena, and what is the motivation behind such efforts.
- She/he can compute simple orbits of satellites using celestial and orbital mechanics, and can apply various celestial coordinate systems.
- The student recognises the basic vocabulary used in space science and technology, and how Aalto University is situated in the national and international space research scenes.

# Workload

# Course structure


**Follow the teaching session listings in section Course schedule in MyCourses.** All you need to know is in MyCourses.

We will have:

- Occasional preliminary work for lectures.
- Live teaching sessions via Zoom.
- Pre-recorded materials and other self-study materials.
- Assignments, quizzes…

# Preliminary course schedule

All changes will be posted in MyCourses!

In MyCourses

| Theory session | Practice session | Topic |
|---|---|---|
| 13.9. Zoom session | (14.9. **no teaching**) | Course introduction & information |
| 20.9. Zoom session | 21.9. Zoom session | Solar system, planets & space environment |
| 27.9. Zoom session | 28.9. Zoom session | Plasma 1: Observations |
| 4.10. Zoom session | 5.10. Zoom session | Plasma 2: Modelling |
| 11.10. Preliminary work + Zoom session | 12.10. Zoom session | Coordinate systems & time |
| 18.10. Zoom session | 19.10. Zoom session | Orbits & celestial mechanics |
| (25.10.) | (26.10.) | Exam week, **no teaching** |
| 1.11. Zoom session | 2.11. Zoom session | Space technology and history |
| 8.11. Self-study | 9.11. Zoom session | Emission mechanisms 1 |
| 15.11. Self-study | 16.11. Zoom session | Emission mechanisms 2 |
| 22.11. Zoom session | 23.11. Zoom session | Galactic astronomy 1 |
| 29.11. Zoom session | 30.11. Zoom session | Galactic astronomy 2 |
| (6.12. **no teaching**) | 7.12. Zoom session | Extragalactic astronomy & cosmology (theory session only) |
| | 14.12. **Exam** | Exam week, exam on 14.12. |

# Course structure

- Theory sessions on Mondays 10-12 via Zoom.
- Practice sessions on Tuesdays 12-14 via Zoom.
  - *Complement the theory sessions, opportunity for questions and discussion.*
  - First practice session: 21.9.2021. Assignment deadlines Tuesdays a week after, at the start of the next practice session at 12.15.
  - **Obey the deadlines for submissions. This means you. Really!**
- Alternatively: pre-recorded and other self-study materials.
- Exam on 14.12.2021.

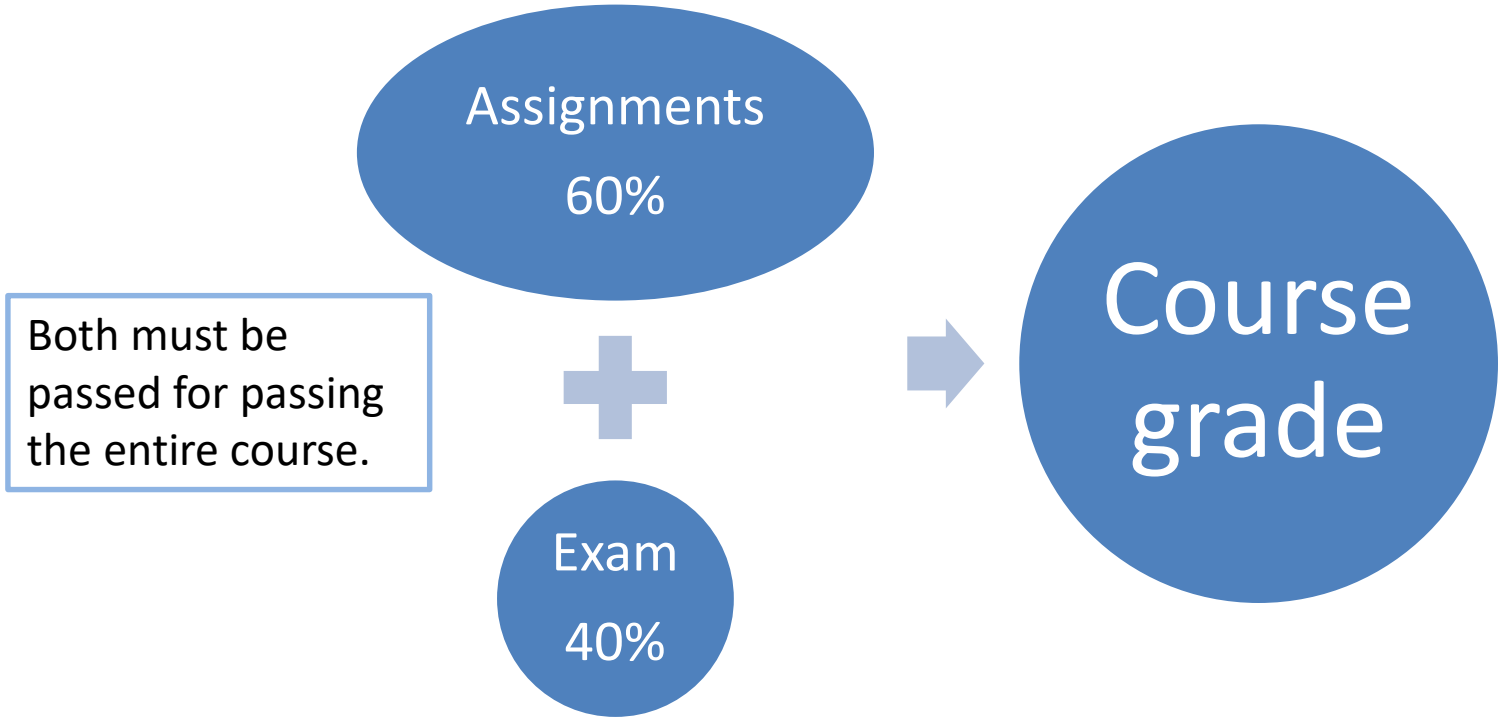
# How to participate in live teaching sessions

- Zoom room for the course can be found in MyCourses in the Course schedule section.
- Always use this link on this course, for both theory and practice sessions.
- We start quarter pass the hour, that is 10.15 or 12.15.
- It is difficult for the teacher to follow chat during lectures so please be patient with possible questions. You can also speak up!

# How to work with self-study materials

- Follow the instructions given for the teaching session. The materials are (usually) given in the order you should study them.
- Self-study materials typically include pre-recorded lectures, links to reading materials, videos, simulations and such, quizzes, assignments as usual…
  - In this case there is usually no live teaching session: always check the course schedule!

# Evaluation and grading



# Space @Aalto

Earth Observation
Space Physics
Radio Astronomy
Space Technology
+Robotics

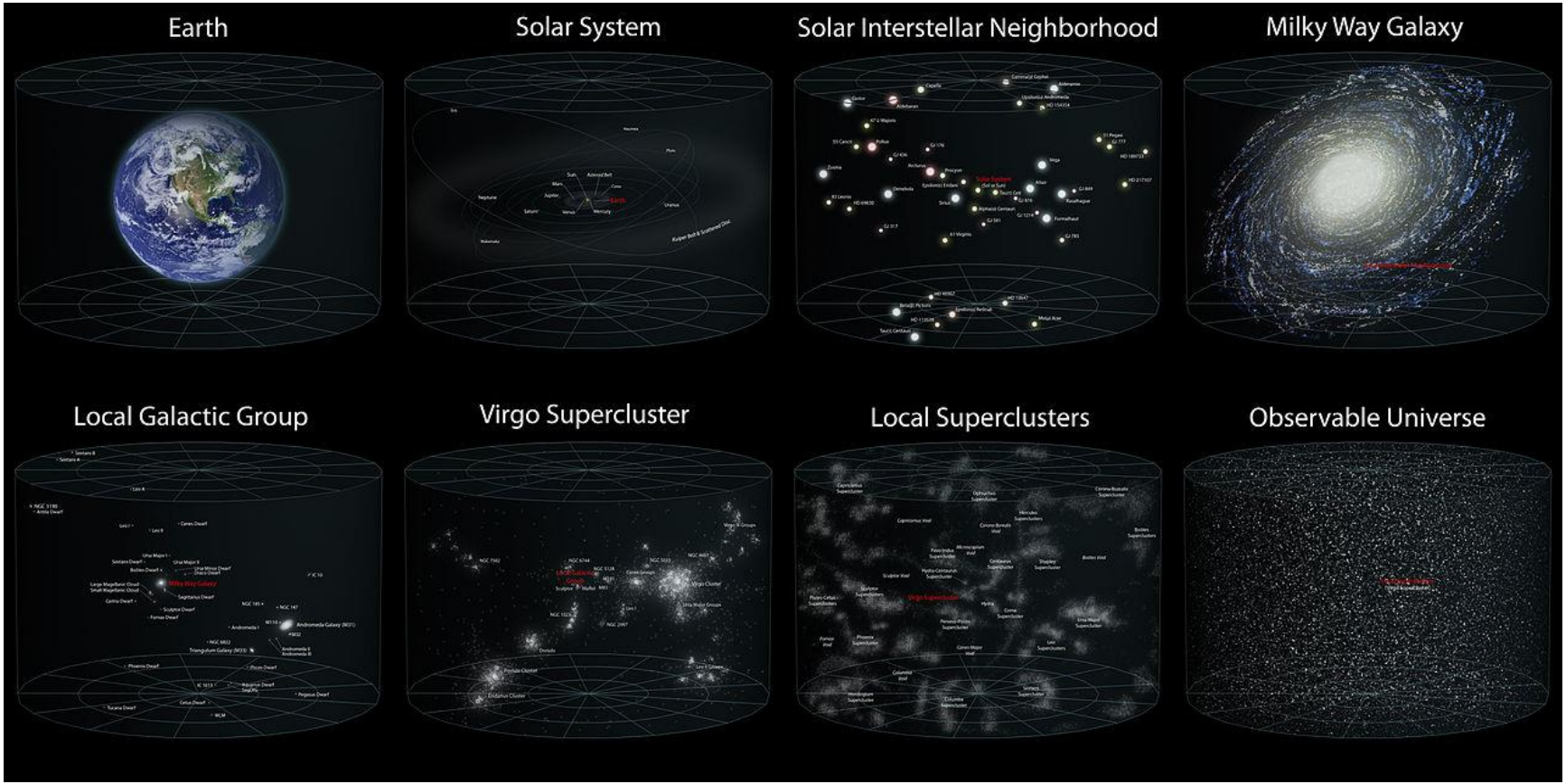
Science:
- Observations
- Theory

Technology:
- Design
- Construction

International community and cooperation

GOAL:
Engineers that understand science; scientists that understand engineering.

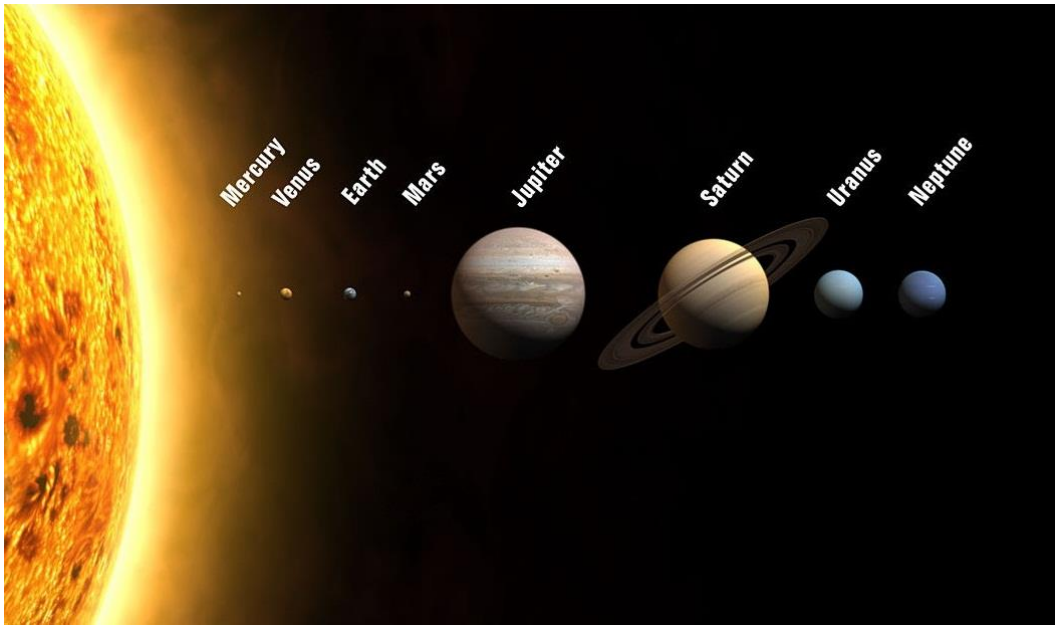
# The Universe




Wikipedia

# Solar system

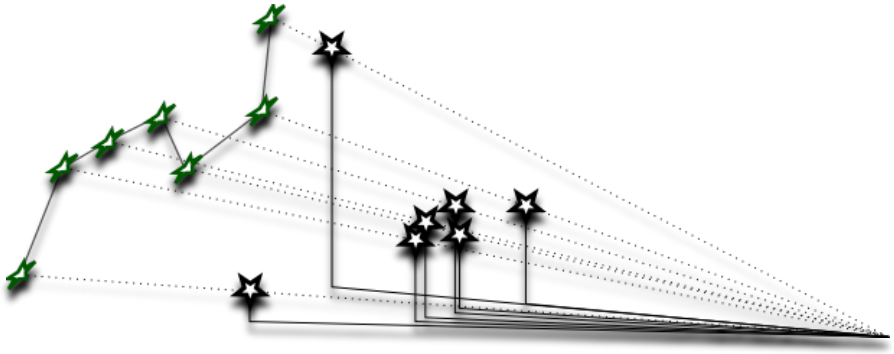
- The Sun
- Planets & moons
- Asteroids
- Meteoroids
- Comets
- Interplanetary dust
- Solar wind




Wikipedia

# Stars

- Constellations, asterisms

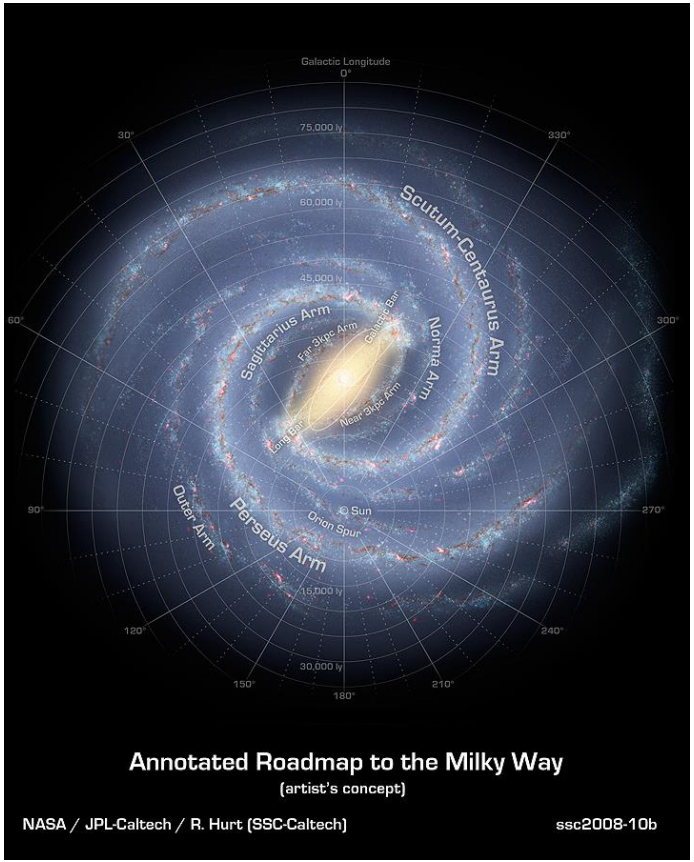


- Star clusters
  - Globular clusters
  - Open clusters

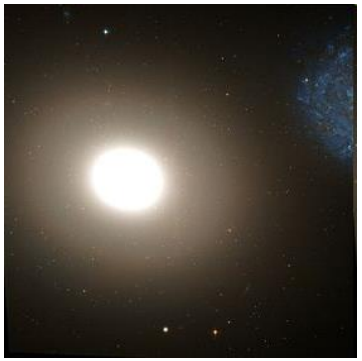
# Galaxies

ESO

The Galaxy aka Milky Way



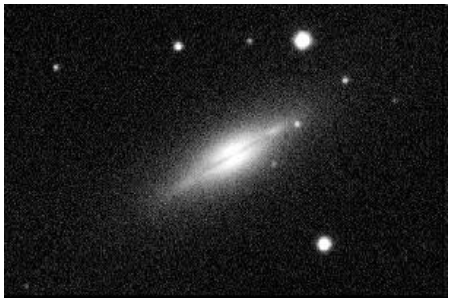
## Elliptical galaxies

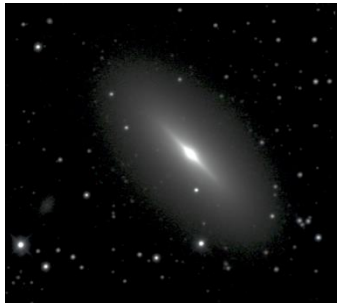


## Spiral galaxies

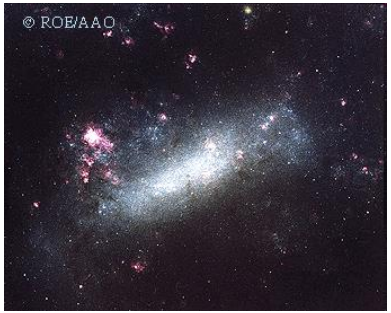


## Lenticular galaxies

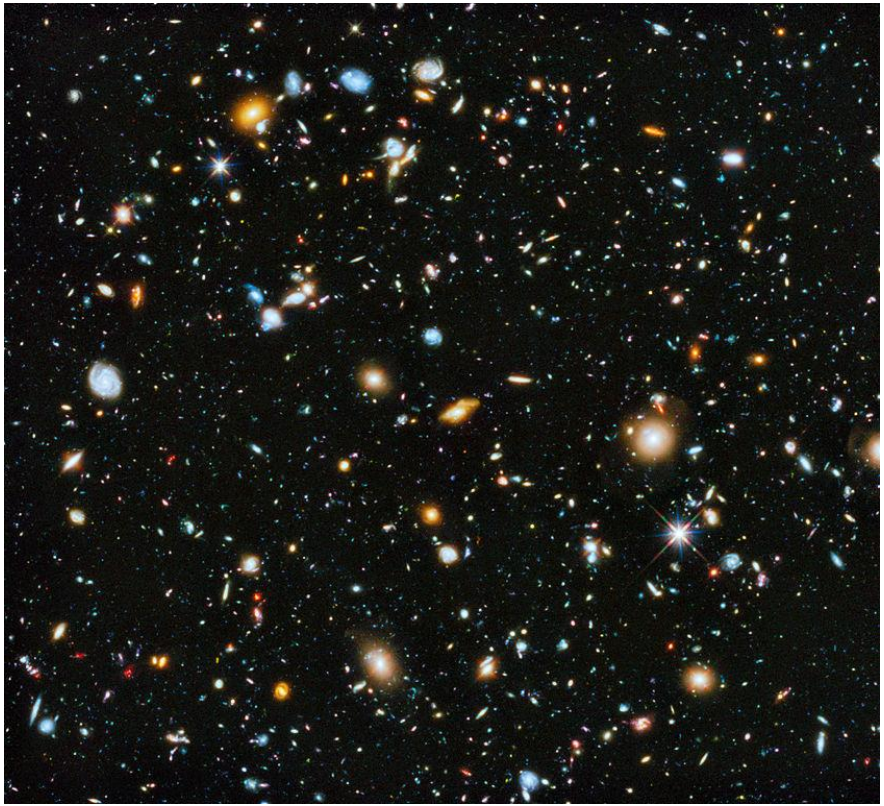




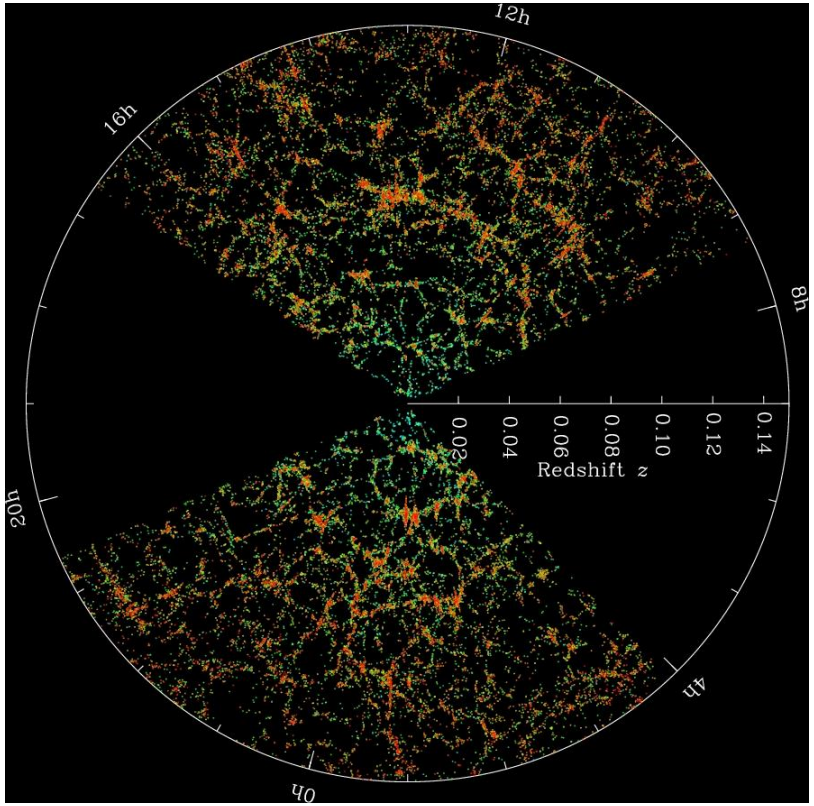
## Irregular galaxies



# Galaxy clusters & large-scale structure



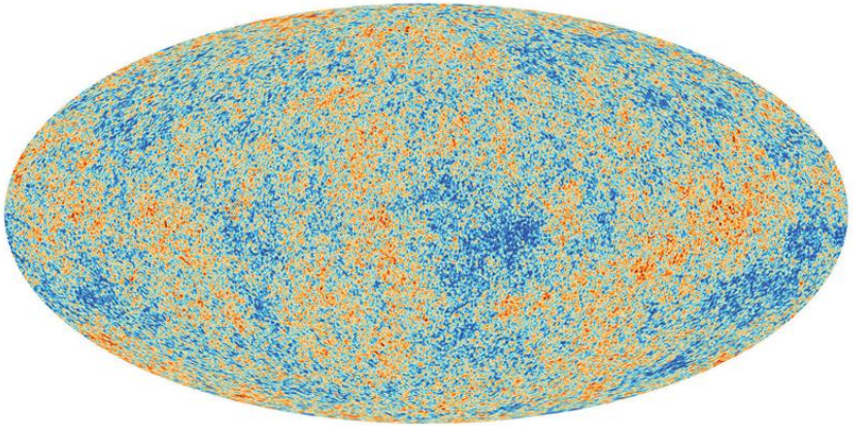
Hubble




SDSS

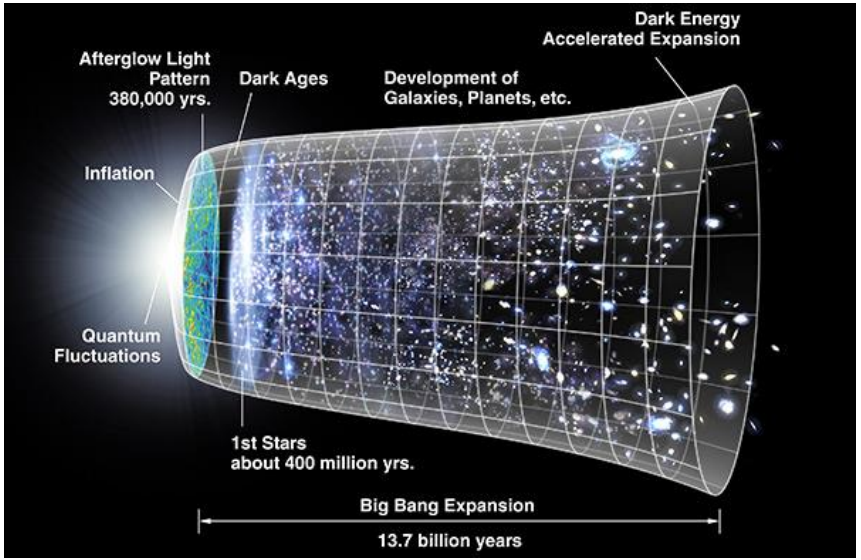
# Cosmology

- Cosmic microwave background, CMB



ESA/Planck

- The age of the Universe is $13.8 \times 10^9$ years




NASA/WMAP

# Dimensions of the Universe:

## Angular measurements

Arcminute (’)

- $1/60^{th}$ of a degree

Arcsecond (’’)

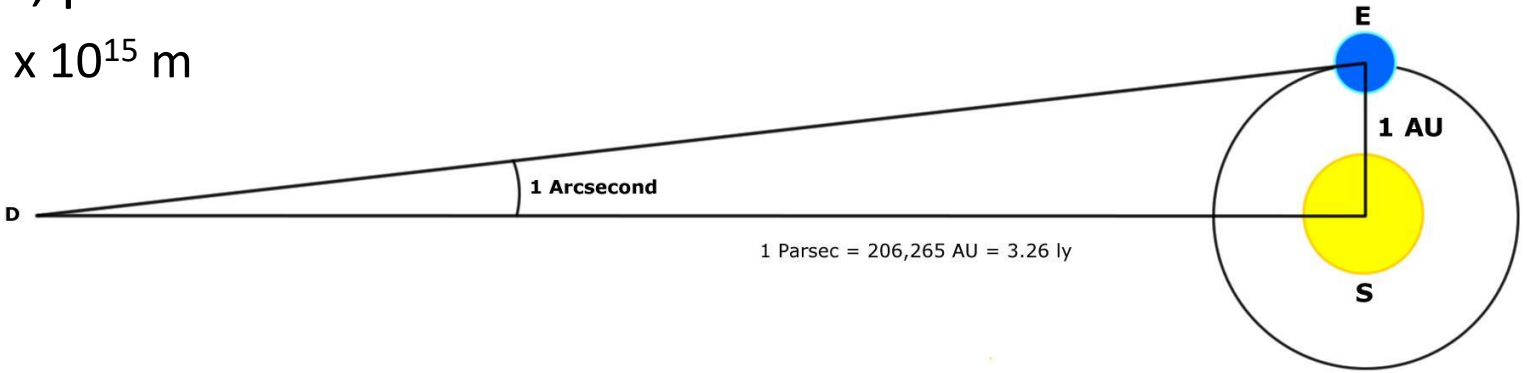
- $1/60^{th}$ of an arcminute

For example:
Moon 0.5° or 30’
Proxima Centauri 0.001’’

# Dimensions of the Universe

- Astronomical Unit, AU
  - $149.6 \times 10^9$ m
- Light year
  - $9.5 \times 10^{15}$ m
- Parsec, pc
  - $31 \times 10^{15}$ m

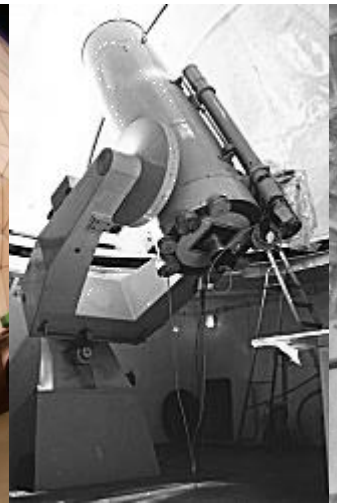
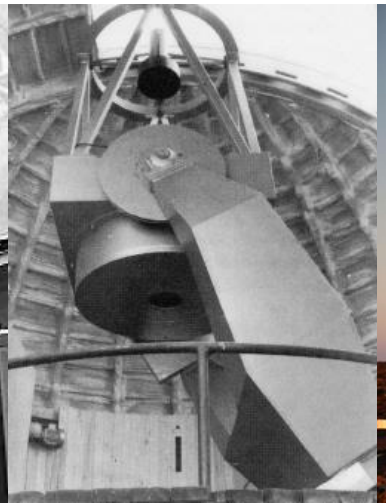
- Distance to the Sun 8.3 light minutes
- Distance to Pluto 5.5 light hours
- Distances between stars ~pc
- Diameter of the Milky Way ~30 kpc
- Largest galaxies ~100 kpc
- Distances between galaxies ~Mpc
- Observable Universe > $28 \times 10^9$ pc



# Astronomy in Finland

- Aalto, Universities of Turku, Helsinki and Oulu
- Astronomy/astrophysics, planetary science, cosmology
  - Instrumentation: radio, optical (+TeV)

Metsähovi (KVA) (Tuorla) MAGIC

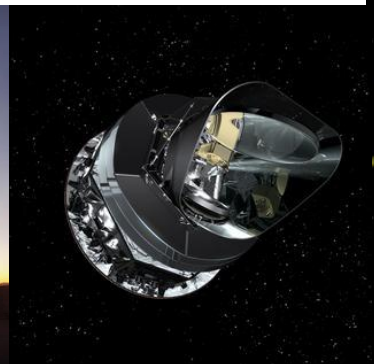

# Astronomy in Finland

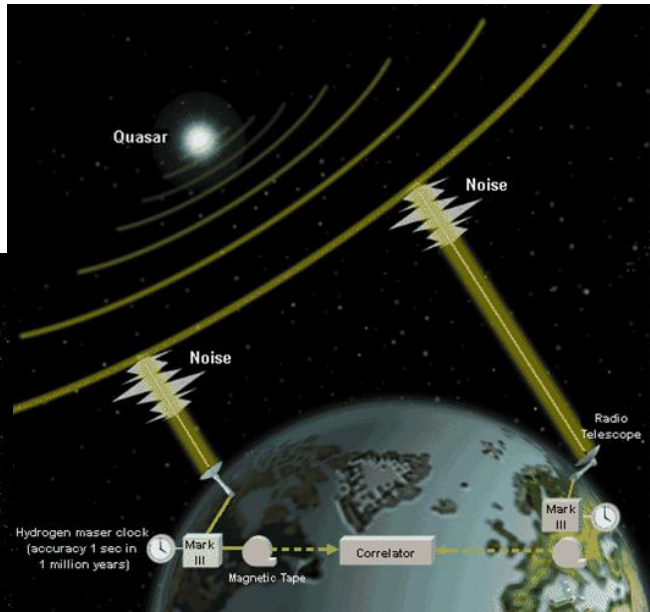
- International instrumentation: radio, optical, IR, UV, X-rays, gamma-rays, TeV
- Ground-based, satellites (ESA, NASA…) , networks (such as Very Long Baseline Interferometry, VLBI)

Fermi

VERITAS

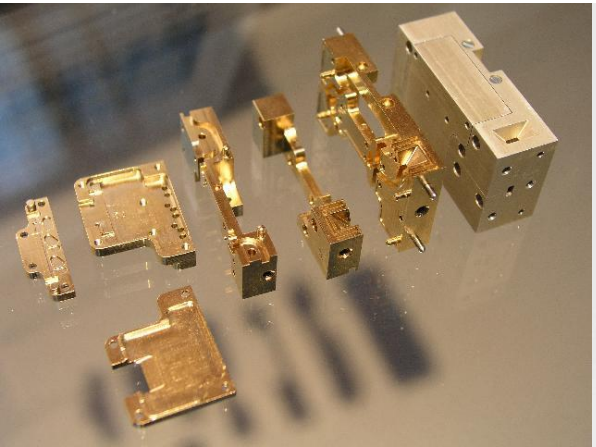
Planck

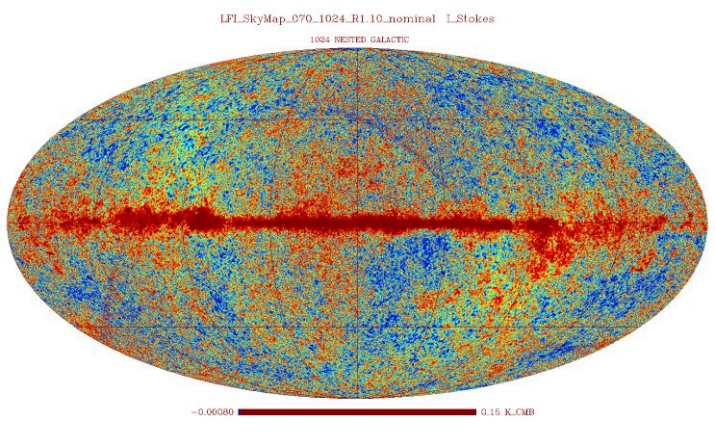




# Astronomical instrument building

- Receivers, software and data transfer technology at Metsähovi
- Planck 70 GHz receiver at Millilab, DA-Design, Metsähovi etc
- X-rays (Helsinki)
- Solar system (FMI, Aalto, Helsinki, Oulu, Turku; Esa K!)





# European Southern Observatory ESO

- Three observatory sites in Chile: La Silla, Paranal, Chajnantor

# ESO

- Finnish Centre for Astronomy with ESO, FINCA
- Research, careers, training

SEST: until 2003

APEX

E-ELT: 2025