PHYSICS

# ASM460 Radioastronomical Techniques and Interferometry, 7.5 higher education credits

Radioastronomical Techniques and Interferometry, 7,5 högskolepoäng

*Second Cycle*

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## Confirmation

This course syllabus was confirmed by Department of Physics on 2008-09-16 and was last revised on 2017-05-22 to be valid from 2017-05-22, spring semester of 2017.

*Field of education:* Science 100%
*Department:* Physics

## Position in the educational system

The course ASM460 is a programme course in the Physics Master Programme, as well as a single subject course at the University of Gothenburg.

The course can be part of the following programmes: 1) Complex Adaptive Systems, Master's Programme (N2CAS), 2) Physics of Materials and Biological Systems, Master's Programme (N2PMB) and 3) Physics, Master's Programme (N2PHY)

| *Main field of studies* | *Specialization* |
|---|---|
| Physics | A1N, Second cycle, has only first-cycle course/s as entry requirements |

## Entry requirements

To be eligible for the course the student needs knowledge in mathematics and physics (including basic electromagnetism) equivalent to a Bachelor degree. English B level or English proficiency equivalent to IELTS 6.5 no part under 5.5 or TOEFL 575 p, TWE score 4.5 is also required.

## Learning outcomes

Students who have followed the course ASM460 Radioastronomical techniques and interferometry will:

- describe the basic operation of a radio telescope and its instrumentation relate the properties of various astronomical objects (e.g. AGNs, pulsars, masers, molecular clouds, the CMB) to requirements on astronomical instrumentation such as receivers and telescopes
- select an appropriate observational technique (e.g. frequency - beam - position switching, polarization measurements, fast scanning) for a given astronomical object
- perform basic analysis of single dish data (e.g. spectral line analysis and identification, dynamical and intensity mapping)
- plan, carry out and evaluate a single dish astronomical experiment
- visualise for a simple two element ('non-tracking') interferometer observing at the zenith, the input responses due to point sources at different positions and strength
- show that it measures one Fourier component of the brightness distribution
- describe to others what is meant by 'spatial frequency' in connection with 2D Fourier transforms
- visualise and write computer programs showing that a single interferometer baseline samples an ellipse in the u,v plane
- explain how the dirty image is made and show mathematically that it isthe convolution of true source with dirty beam
- explain how an East-West interferometer can be constructed to minimise side-lobes
- explain how closure phases are used to recover phase in redundant arrays and how 'hybrid mapping' works
- describe similarities and difference of radio interferometry with phased arrays (i.e in antenna engineering) and Synthetic Aperture Radar (radar remote sensing).
- understand the principles of geodetic VLBI as space geodetic technique and its uniqueness for geosciences
- explain the VLBI data correlation and terms like delay-tracking and fringestopping
- determine the expected accuracy that can be derived for specific geodtic parameters as a function of network geometry and technical setup
- understand the principles of geodetic VLBI analysis

**Course content**

The aim of the course is that students are to attain basic understanding of advanced techniques in radioastronomy. This includes both single dish operations and interferometry. The course shall enable the students to plan an astronomical experiment using interferometry, and to determine the required integration time, choice of interferometer (resolution, maximum size of mapable structure, fidelity of image). They should learn to go from raw astronomy interferometry data to a final image. Furthermore, the course also aims at providing the students with basic knowledge in interferometry for geodesy. The level of understanding should be such that the students in their profession as engineers should be able to actively apply radioastronomical techniques.

The course contains the following parts:

- Single dish radioastronomy
- Fundamental concepts
- Basic antenna theory
- Receiver and signal processing
- Observational methods
- Radioastronomical objects
- Spectral line analysis
- Data handling
- Radio Interferometry for Astronomy and Geodesy
- VLBI correlation
- The 2-element non-tracking interferometer
- The tracking interferometer
- The 2D Fourier transforms
- The aperture plane or 'uv' coverage for example interferometers
- The dirty map and dirty beam
- Deconvolution methods
- Phase errors and their recovery using closure phase and self-calibration
- Comparisons with phased arrays and Synthetic Aperture Radar (SAR)
- Geodetic VLBI data analysis

**Form of teaching**

The course is organized in problem classes, practical observations, and computer excercises.

*Language of instruction:* English

**Assessment**

The examination is in the form of a written examination and hand-in assignments.

A student who has failed a test twice has the right to change examiner, unless weighty argument can be adduced. The application shall be sent to the board of the department and has to be in writing.

### Grades
The grading scale comprises: Pass with Distinction (VG), Pass (G) and Fail (U).

### Course evaluation
The results of the evaluation will be communicated to the students and will function as a guide for the development of the course.

### Additional information
The course is given jointly with Chalmers University of Technology. The Chalmers code for the course is RRY130.