Course instruction – Radio-Astronomical Interferometry

Presented by

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Welcome to our online course “Radio-Astronomical Interferometry”.

This manual is supposed to help you navigate through the website and will provide some additional information about the course. If anything is unclear feel free to either look up the FAQs or contact the course supervisor via mail.

Within only a few decades in the 19th century, radio astronomy has rapidly gained high importance within astronomy. Especially the use of radio telescope arrays, along with the dramatically increased possibilities of information technology, has enabled a variety of ambitious and forward-looking projects which delivered spectacular results. Recent examples are the most detailed image ever of the Galactic Center with MeerKAT, a pilot project of the international Square Kilometer Array (SKA), or the first image of the shadow of a black hole by the global Event Horizon Telescope (EHT). Other selected important examples for radio telescope arrays are the Atacama Large Millimeter/submillimeter Array (ALMA) and the European Low-Frequency Array (LOFAR). The basis for all these measurements is radio interferometry, which also plays an important role for geodesy, since it allows high-precision measurements of the position and orientation of Earth in space. For this purpose, three radio telescopes are operated by the Bundesamt für Kartographie and TUM in Wettzell in the Bavarian Forest. Radio interferometry is a complex technique on a mathematical, information technological and physical level. Understanding radio-interferometric methods is also of interest to computer scientists who want to gain experience in the field of big data, since the next generation of radio interferometers, e.g., LOFAR and SKA, generate data amounts in the range of several 100 petabytes per day which corresponds to the entire amount of data stored by Google, Facebook and Microsoft together.

This course is divided into four chapters: Motivation and Background, Fundamental Concepts, Special Applications & Challenges and Technical realization: Current and Upcoming Radio Interferometers.

A concept of this online course is the close interaction between the theory as well as tutorials and hands-on exercises using radio data. This happens through the combination of lectures which cover the theoretical basics, complemented by step-by-step tutorials where the students learn how to reconstruct images from radio interferometrical data.
In addition, frequent learning quizzes throughout the lecture (multiple-choice tests) provide feedback about personal learning success.
The aim of the course is to provide a basic understanding of radio interferometry and its methods.

The processing time of this course is 14 weeks.

NOTE: *The registration of the course has to be done online via the VHB-homepage!*
Please also check the information about dates and deadlines announced by the VHB in the course description. You are requested to ***inform yourself whether and how credit points*** *or certificates of performance for this course* ***will be taken into account*** *by your home university. The examination office at your home university will be happy to answer your questions.*

Students will acquire the following skills:

- Understanding of the concept of interferometric observations and their calibration
- Processing and interpretation of raw data
- Data reduction and data analysis
- Application and understanding of established algorithms
- Handling large amounts of data
- Reconstructing images from radio-interferometrical data using the program DIFMAP
- Intensified handling of English as a scientific language

Thank you for participating! Best wishes,
Your supervisor-Team

Alexander Kappes, Florian Rösch, Hrishikesh Shetgaonkar, Matthias Kadler & Jörn Wilms

Content of the course

This course is divided into ***four chapters***:

1. Motivation and Background (Weeks: 1, Sections: 3)
2. Fundamental Concepts (Weeks: 4, Sections: 6)
3. Special Applications and Challenges (Weeks: 4, Sections: 8)
4. Technical realization: Current and Upcoming Radio Interferometers (Weeks: 2, Sections: 4)

Each of these courses is divided into sections and subsections.

At the end of each Chapter there is a ***short multiple choice quiz***. It will give a short feedback to whether the students have understood the major conclusions of the previous chapter. After completing this quiz the student can proceed to the next chapter.

Furthermore there will be ***four exercises***. They are announced in the “Forum for Announcements” at the front page of the course.
The *first two exercises* (1 & 2) will be uploaded in the form of a PDF document. These sheets contain a few tasks which require knowledge of theoretic part of the lectures. The students are supposed to solve the exercise (as far as they can) and hand in the solution in form of a PDF document. The corrected version of the exercises will be returned one week after being handed in.
The *second two exercises* (3 & 4) are the practical part of the lecture where the students get the chance to work with radio data. These exercises can only be done with the software DIFMAP. Because the installation of DIFMAP is rather tricky this course offers a virtual container (a Linux computer within a program on your computer) in which DIFMAP (and all the data needed for the exercises) are already installed. An instruction about how to install and run this container can be found in the folder “How to start this course”. Again the exercises will be announced via the “Forum for Announcement”. The students are given a task and are supposed to analyse a data set with DIFMAP. Once the exercise is finished the project will be saved by DIFMAP as a .fits / .par / .win / .mod / .uvf file. Once again the exercise can be handed in via uploading these files (as zip or tar data).

The ***final exam*** will be similar to a combination of the exercises. A folder including multiple files will be sent via email to students who want to participate in the exam on the day of the exam. It will contain a manual, a task sheet with questions about the lecture and radio data that can be analysed with DIFMAP. The answers to the exercises of the exam must be uploaded during the same day at which the exam will take place. The submission of these answers is the basis of the final grade. Details and date of the exam will be announced in time.

Prerequisites for passing the course

The only prerequisite for a participation in the final examination is the enrolment in the online course.

However it is highly recommended to participate in the course by doing the exercises and quizzes. The completion of the listed learning quizzes and exercises is not a prerequisite for admission for the final exam but it guarantees a continuous self-monitoring of the individual learning success. Furthermore it provides an appropriate preparation for the final exam.

Examination modalities

Authorized examiners: Prof. Dr. Matthias Kadler, Prof. Dr. Joern Wilms
Type of exam: Exam
Examination material: The exam refers to the contents of the online lecture “Radio-Astronomical Interferometry” as well as the accompanying tutorials and exercises.
Examination literature: Online-lecture and the literature listed within
(see also the bibliography provided on the front page of this course)
Number of SWS: 3+1
ECTS credits: 6
Preparation time for the exam: 1 day
Submission date: Will be announced via course forum

NOTE: *The registration of the exam has to be done at your home institution accordant to its examination formalities! In addition, please write an email to the tutor of the course and Prof. Dr. Matthias Kadler.*