GHENT UNIVERSITY

Course Specifications

Valid in the academic year 2024-2025

Radiative Transfer Simulations in Astrophysics (C003939)

Course size *(nominal values; actual values may depend on programme)*

Credits 6.0 **Study time 180 h**

Course offerings in academic year 2024-2025

null

Lecturers in academic year 2024-2025

Baes, Maarten	WE05	lecturer-in-charge

Offered in the following programmes in 2024-2025	crdts	offering
null		

Teaching languages

English

Keywords

Astrophysics, radiative transfer, numerical modeling, Monte Carlo techniques, interstellar dust

Position of the course

Astronomical observations are naturally limited to the two-dimensional plane of the sky. Building a computer model of the observed objects can help us understand the underlying three-dimensional structure and physical processes. These models must properly take into account the effects of radiation transport through the interstellar medium. For example, in an average spiral galaxy, one third of the stellar radiation is absorbed by interstellar dust. The Monte Carlo technique is the most popular method to accurately simulate these effects.
This course is the logical next step after "Astrophysical Simulations". In that course, students are initiated in the art of scientific programming, focusing on simulation techniques for gravitation and hydrodynamics. This follow-up course studies simulation techniques for radiation transport, another phenomenon that is important in almost all astrophysical systems. Furthermore, the practical sessions provide a realistic setting where the student learns how to use an existing scientific code and adjust or extend it to achieve new, specific research goals.

Contents

1 The radiative transfer problem
2 Dust radiative transfer
3 X-ray radiative transfer
4 Random number generation
5 Simple monochromatic Monte Carlo radiative transfer
6 Weighted monochromatic Monte Carlo radiative transfer
7 Panchromatic Monte Carlo radiative transfer
8 The SKIRT code
9 Spatial grids
10 Geometric building blocks in SKIRT
11 Parallelisation
12 Radiative transfer benchmarks
13 The 3D structure of galaxies
14 The torus in active galactic nuclei
15 Synthetic observations for simulated galaxies

Initial competences

Astrophysical Simulations (C002329)

Final competences

1 Derive the radiative transfer equation and understand its components.
2 Describe the Monte Carlo photon package life cycle and related techniques for spatial discretization, sampling from three-dimensiomal distributions, computational optimization, and parallelization.
3 Describe some science cases to which to radiative transfer simulations are applied and explain why they are relevant.
4 Apply a state-of-the-art radiative transfer code to basic science cases.
5 Interpret radiative transfer simulation results in a numerical and astrophysical context.
6 Orally convey the findings of a radiative transfer simulation project to experts.

Conditions for credit contract

Access to this course unit via a credit contract is determined after successful competences assessment

Conditions for exam contract

This course unit cannot be taken via an exam contract

Teaching methods

Lecture, Independent work

Extra information on the teaching methods

Part of the material is prepared by the student before the lecture and is reviewed during the lecture. Other parts of the material are explained in detail during the lectures.

Study material

Type: Syllabus

Name: Radiative transfer
Indicative price: Free or paid by faculty
Optional: no
Language : English
Number of Pages : 200
Available on Ufora : Yes
Online Available : Yes
Available in the Library : No
Available through Student Association : No

Type: Slides

Name: Radiative transfer
Indicative price: Free or paid by faculty
Optional: no
Language : English
Number of Slides : 200
Available on Ufora : Yes
Online Available : Yes
Available in the Library : No
Available through Student Association : No

References

Monte Carlo Methods, Malvin H. Kalos and Paula A. Whitlock, Second Edition, 2008 Wiley-VCH.
Three-Dimensional Dust Radiative Transfer, Juergen Steinacker, Maarten Baes, and Karl D. Gordon, 2013, Annual Review of Astronomy and Astrophysics.
SKIRT: An advanced dust radiative transfer code with a user-friendly architecture, Peter Camps and Maarten Baes, 2015, Astronomy and Computing.

Course content-related study coaching

The lecturers are available for coaching during the semester.

Assessment moments

end-of-term and continuous assessment

Examination methods in case of periodic assessment during the first examination period

Oral assessment, Assignment

Examination methods in case of periodic assessment during the second examination period

Oral assessment, Assignment

Examination methods in case of permanent assessment

Assignment

Possibilities of retake in case of permanent assessment

examination during the second examination period is not possible

Extra information on the examination methods

The non-periodic evaluation relates to a modest-size individual programming project.
The period evaluation relates to a project in which the student applies the SKIRT radiative transfer code to an astrophysical question. The results of this project are presented in a document and an oral presentation.

Calculation of the examination mark

Programming project: 30%
Radiative transfer project: 70%

Facilities for Working Students

The syllabus and the slides are available on Ufora. Independent work is an integral part of this course.