UNSW Course Outline

PHYS3116 Galaxies and Cosmology - 2024

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General Course Information

Course Code : PHYS3116
Year : 2024
Term : Term 3
Teaching Period : T3
Is a multi-term course? : No
Faculty : Faculty of Science
Academic Unit : School of Physics
Delivery Mode : In Person
Delivery Format : Standard
Delivery Location : Kensington
Campus : Sydney
Study Level : Undergraduate
Units of Credit : 6

Useful Links
Handbook Class Timetable

Course Details & Outcomes

Course Description

Data from the Hubble Space Telescope has been used to produce stunning images of other galaxies, highlighting their dramatic diversity. From massive spiral galaxies like the Milky Way to compact elliptical galaxies where star formation has long since ceased, observations of galaxies provide clues about the origins of the Universe and how it has evolved over the past 14 billion years.

In this course, students will understand the structure and kinematics of the most well-studied galaxy, the Milky Way, and how it has developed over time, informed by a comparison to other galaxies over cosmic time. Students will also learn how modern astronomical surveys have transformed our understanding of the Universe and our Galaxy's place in it. Topics to be covered include: structure and kinematics of the Milky Way, fundamental properties of galaxies, galactic chemical evolution, expansion of the Universe, star formation history and formation of galaxies, effects of galaxy mergers, epoch of reionisation, evidence for dark matter and dark energy, and cosmological models.

The course is intended primarily for Level 3 undergraduates taking a Physics major, for which this course is an elective, and consists of both lectures and tutorials.

Course Aims

The aim of this course is to give students an introduction to the current state of knowledge about galaxies, their physical parameters, how they behave and how they evolve in their broader context within the Universe. Galaxies are the basic building block of the Universe, and are a fundamental scale on which structure is found in the Universe. This course provides an introduction to the physics impacting the formation, dynamics and evolution of galaxies and the Universe more broadly, i.e., cosmology. The basic mathematical formalism governing the physics of "Big Bang" cosmology is presented, though the detailed solution of the equations is not attempted.

Students will develop key research skills, including tackling open-ended problems, working collaboratively with peers and scientific writing.

Relationship to Other Courses

PHYS3116 is part of the astronomy minor set of courses (along with PHYS1116, PHYS2116). While PHYS1116 and PHYS2116 are not pre-requisites for PHYS3116, there is some assumed knowledge that will only be briefly reviewed in class. Resources will be shared to learn those concepts during class.

In PHYS3116, the topic of cosmology will be approached through a computational and observational angle as typical in the field of astronomy. PHYS3115 focuses on the early universe and a theoretical approach to cosmology. The two courses are complementary.

Course Learning Outcomes

Course Learning Outcomes
CLO1 : Use mathematical and computational skills to quantitatively interpret the structure, formation, and kinematics of the Milky Way compared to other galaxies and characterise the beginnings and ultimate fate of the Universe.
CLO2 : Critically evaluate new hypotheses in the primary extragalactic astrophysics and cosmology scientific literature.
CLO3 : Design an analysis of astrophysical datasets to reproduce seminal studies in extragalactic astrophysics or cosmology.
CLO4 : Apply the tools that are used by professional astronomers in the analysis of galaxies and cosmology.
CLO5 : Effectively communicate scientific concepts, both individually and as part of a collaborative team.

Course Learning Outcomes	Assessment Item
CLO1 : Use mathematical and computational skills to quantitatively interpret the structure, formation, and kinematics of the Milky Way compared to other galaxies and characterise the beginnings and ultimate fate of the Universe.	• Problem Sets • Computational Assignment • Written Report • Final Exam
CLO2 : Critically evaluate new hypotheses in the primary extragalactic astrophysics and cosmology scientific literature.	• Written Report • Final Exam
CLO3 : Design an analysis of astrophysical datasets to reproduce seminal studies in extragalactic astrophysics or cosmology.	• Computational Assignment • Written Report
CLO4 : Apply the tools that are used by professional astronomers in the analysis of galaxies and cosmology.	• Problem Sets • Computational Assignment • Final Exam • Written Report
CLO5 : Effectively communicate scientific concepts, both individually and as part of a collaborative team.	• Problem Sets • Computational Assignment • Written Report

Learning and Teaching Technologies

Moodle - Learning Management System | Echo 360

Assessments

Assessment Structure

Assessment Item	Weight	Relevant Dates
Problem Sets Assessment Format: Individual Short Extension: Yes (7 days)	20%	Start Date: Weeks 2 and 7. Due Date: Week 4: 30 September - 06 October, Week 9: 04 November - 10 November
Computational Assignment Assessment Format: Group Short Extension: Yes (7 days)	20%	Due Date: Week 5: 07 October - 13 October
Written Report Assessment Format: Individual Short Extension: Yes (3 days)	30%	Due Date: Week 10: 11 November - 17 November
Final Exam Assessment Format: Individual	30%	

Assessment Details

Problem Sets

<u>**Assessment Overview**</u>

Two problem sets will be distributed across the term, typically Weeks 2 and 7, based on the materials covered in the course up to that point. You will have two weeks to complete each of the problem sets.

The assignments will be marked and returned to you within 2 weeks.

Solutions will be posted on Moodle when all assignments have been turned in.

<u>**Course Learning Outcomes**</u>

- CLO1 : Use mathematical and computational skills to quantitatively interpret the structure, formation, and kinematics of the Milky Way compared to other galaxies and characterise the beginnings and ultimate fate of the Universe.
- CLO4 : Apply the tools that are used by professional astronomers in the analysis of galaxies and cosmology.
- CLO5 : Effectively communicate scientific concepts, both individually and as part of a collaborative team.

<u>**Assignment submission Turnitin type**</u>

This assignment is submitted through Turnitin and students can see Turnitin similarity reports.

Generative AI Permission Level

Simple Editing Assistance

In completing this assessment, you are permitted to use standard editing and referencing functions in the software you use to complete your assessment. These functions are described below. You must not use any functions that generate or paraphrase passages of text or other media, whether based on your own work or not.
If your Convenor has concerns that your submission contains passages of AI-generated text or media, you may be asked to account for your work. If you are unable to satisfactorily demonstrate your understanding of your submission you may be referred to UNSW Conduct & Integrity Office for investigation for academic misconduct and possible penalties.
For more information on Generative AI and permitted use please see here.

Computational Assignment

Assessment Overview

In groups of 2 or 3, you will perform a guided analysis of data from astronomical surveys to measure fundamental parameters of galaxies and understand how observations of extragalactic phenomena are collected and analysed in practice.

You will have the option to select between two observational datasets to analyse for this computational assignment, with instructions and marking rubric to be distributed early in the term.

You will have 5 weeks to complete the assignment which is typically due in Week 5 and submit a 10 minute video presenting the outcomes for the group. The assignment will be graded against the provided marking rubric.

The videos will be marked and comments will be returned to you within 2 weeks.

Course Learning Outcomes

- CLO1 : Use mathematical and computational skills to quantitatively interpret the structure, formation, and kinematics of the Milky Way compared to other galaxies and characterise the beginnings and ultimate fate of the Universe.
- CLO3 : Design an analysis of astrophysical datasets to reproduce seminal studies in extragalactic astrophysics or cosmology.
- CLO4 : Apply the tools that are used by professional astronomers in the analysis of galaxies and cosmology.
- CLO5 : Effectively communicate scientific concepts, both individually and as part of a collaborative team.

Detailed Assessment Description

A full brief for this assessment will be provided via moodle on Week 1.

This assessment is marked based on "competency grading". To obtain full marks, you must fulfil all described criteria at a competent level. Please refer to the assessment marking grid below for the description of each criterion. Should you fail to achieve a competent level in all criteria, you may resubmit your assessment once with a new deadline of up to 2 weeks from receiving your lecturer's feedback.

Criteria with marking rubric

Criteria: Quantity of science content

Fail -

Pass -

Credit -

Distinction -

High Distinction -

Criteria: Quality and accuracy of science content

Fail -

Pass -

Credit -

Distinction -

High Distinction -

Criteria: Functionality of the analysis and methodology

Fail -

Pass -

Credit -

Distinction -

High Distinction -

Criteria: Structure

Fail -

Pass -

Credit -

Distinction -

High Distinction -

Criteria: Length

Fail -

Pass -

Credit -

Distinction -

High Distinction -

Criteria: Team contribution, motivation and reliability

Fail -

Pass -

Credit -

Distinction -

High Distinction -

Criteria: Delivery

Fail -

Pass -

Credit -

Distinction -

High Distinction -

Assignment submission Turnitin type

This is not a Turnitin assignment

Generative AI Permission Level

Simple Editing Assistance

In completing this assessment, you are permitted to use standard editing and referencing functions in the software you use to complete your assessment. These functions are described below. You must not use any functions that generate or paraphrase passages of text or other media, whether based on your own work or not.

If your Convenor has concerns that your submission contains passages of AI-generated text or media, you may be asked to account for your work. If you are unable to satisfactorily demonstrate your understanding of your submission you may be referred to UNSW Conduct & Integrity Office for investigation for academic misconduct and possible penalties.

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Written Report

Assessment Overview

From provided datasets analysed in the computational assignment, you will write an up to 5-pages long article in the style and format of an astronomical journal article describing how the data provide answers to outstanding problems in extragalactic astrophysics.

You will have five weeks from the submission of the computational assignment to complete the written report which is typically due in Week 10.

The written report will be marked and returned to you within 2 weeks.

Course Learning Outcomes

- CLO1 : Use mathematical and computational skills to quantitatively interpret the structure, formation, and kinematics of the Milky Way compared to other galaxies and characterise the beginnings and ultimate fate of the Universe.
- CLO2 : Critically evaluate new hypotheses in the primary extragalactic astrophysics and cosmology scientific literature.
- CLO3 : Design an analysis of astrophysical datasets to reproduce seminal studies in extragalactic astrophysics or cosmology.
- CLO4 : Apply the tools that are used by professional astronomers in the analysis of galaxies and cosmology.
- CLO5 : Effectively communicate scientific concepts, both individually and as part of a collaborative team.

Detailed Assessment Description

A full assessment brief will be made available on Moodle.

Assessment information

This assessment is marked based on “competency grading”. To obtain full marks, you must fulfil all described criteria at a competent level. Please refer to the assessment marking grid below for the description of each criterion. Should you fail to achieve a competent level in all criteria, you may resubmit your assessment once with a new deadline of up to 1 week from receiving your lecturer’s feedback.

Criteria with marking rubric

Criteria: Structure and Flow

Fail -

Pass -

Credit -

Distinction -

High Distinction -

Criteria: Broader context and literature

Fail -

Pass -

Credit -

Distinction -

High Distinction -

Criteria: Clarity and precision of language

Fail -

Pass -

Credit -

Distinction -

High Distinction -

Criteria: Use of figures and captions

Fail -

Pass -

Credit -

Distinction -

High Distinction -

Criteria: Interpretation of results

Fail -

Pass -

Credit -

Distinction -

High Distinction -

Criteria: Logic of discussion and conclusion

Fail -

Pass -

Credit -

Distinction -

High Distinction -

Assignment submission Turnitin type

This assignment is submitted through Turnitin and students can see Turnitin similarity reports.

Generative AI Permission Level

Planning/Design Assistance

You are permitted to use generative AI tools, software or services to generate initial ideas, structures, or outlines. However, you must develop or edit those ideas to such a significant extent that what is submitted is your own work, i.e., what is generated by the tool, software or service should not be a part of your final submission. You should keep copies of your iterations to show your Course Authority if there is any uncertainty about the originality of your work.
If your Convenor has concerns that your answer contains passages of AI-generated text or media that have not been sufficiently modified you may be asked to explain your work, but we recognise that you are permitted to use AI generated text and media as a starting point and some traces may remain. If you are unable to satisfactorily demonstrate your understanding of your submission you may be referred to UNSW Conduct & Integrity Office for investigation for academic misconduct and possible penalties.
For more information on Generative AI and permitted use please see here.

AI can be a great tool to enhance your writing, check your grammar and provide a starting point. That said, AI cannot understand and adequately describe your own work. An AI detection algorithm will be applied to all submitted assessments. Be sure to adequately acknowledge the use of AI and ask yourself whether the use is appropriate in your context to demonstrate you have achieved the competency goals of the assessment. Refer to the University documentation on the use of AI for assessments.

Final Exam

Assessment Overview

You will sit a 2-hour final exam during the formal examination period.

The final Exam will cover the material taught during the lectures. Questions and problems are typically similar in style and scope to those found in the Problem Sets and discussed during tutorials.

Feedback is available through inquiry with the course convenor.

Course Learning Outcomes

- CLO1 : Use mathematical and computational skills to quantitatively interpret the structure, formation, and kinematics of the Milky Way compared to other galaxies and characterise the beginnings and ultimate fate of the Universe.
- CLO2 : Critically evaluate new hypotheses in the primary extragalactic astrophysics and

cosmology scientific literature.
- CLO4 : Apply the tools that are used by professional astronomers in the analysis of galaxies and cosmology.

Detailed Assessment Description

The final exam will be problems in a similar style to the problem sets. Doing and reviewing the problem sets as well as some example problems from last year's final exam is thus the best way to prepare for the invigilated final exam.

Assignment submission Turnitin type

Not Applicable

Generative AI Permission Level

No Assistance

This assessment is designed for you to complete without the use of any generative AI. You are not permitted to use any generative AI tools, software or service to search for or generate information or answers.
For more information on Generative AI and permitted use please see here.

General Assessment Information

Information about Special Consideration is available from https://student.unsw.edu.au/special-consideration

Further information

UNSW grading system: student.unsw.edu.au/grades

UNSW assessment policy: student.unsw.edu.au/assessment

Assessment criteria and standards

Please see Moodle for a marking details for each assessment task.

Submission of assessment tasks

Unless otherwise specified, assignments should be submitted via Moodle/Turnitin by the specified time and date on Moodle for the given task. Assignments will not be accepted in hard-copy form or via email. Marks will be deducted for late assignments according to university policy.

Feedback on assessment

Please see Moodle for details on how feedback will be provided for each assessment task.

<u>Grading Basis</u>

Standard

<u>Requirements to pass course</u>

The computational assessment and the written report will be graded by competency. This means that full marks will be granted once all criteria are met. Students will have an opportunity to re-submit those assessments up to 1 week after feedback from lecturer has been given. Together, these two assessments contribute 50% of your final mark.

The problem sets and final exams are marked in the traditional way, i.e. numerical grading. These are used for ranking and give students a chance to shine.

Course Schedule

Teaching Week/Module	Activity Type	Content
Week 1 : 9 September - 15 September	Lecture	What is the Milky Way? What is our place in the galaxy? Fundamental properties and major components of the Milky Way. Galactic rotation, globular clusters. Evidence for supermassive black holes. The cosmic distance ladder. Oort constants and galactic potentials. Density wave theory.
Week 2 : 16 September - 22 September	Lecture	How do stars vary across galaxies and across time, and what does that tell us about galaxies? Is the Milky Way normal? Galactic archaeology, galactic chemical evolution. Satellite galaxies and the Magellanic clouds. Types of galaxies and basic properties. Tully-Fisher and Faber-Jackson relations. The Fundamental plane. Large-scale stellar surveys for galactic archaeology.
Week 3 : 23 September - 29 September	Lecture	How do galaxies evolve? Look-back techniques. Galaxy number counts, cluster and field galaxy evolution, redshift surveys, bulk motions amongst galaxies. Spectra of galaxies and large galaxy surveys. The galactic fountain. Formation of elliptical galaxies.
Week 4 : 30 September - 6 October	Lecture	What can the first galaxies teach us about the universe? Star formation history of the universe and variations in the stellar initial mass function. The first galaxies, dropout galaxy detection methods. Spectra of galaxies and large galaxy surveys (continued). Active galactic nuclei.
Week 5 : 7 October - 13 October	Lecture	What can other galaxies and their environments teach us about the universe? What is dark matter? Clusters and superclusters, lensing, its effects. The Press-Schechter function. Evidence for dark matter and the ongoing search for dark matter candidates.
Week 6 : 14 October - 20 October	Other	Flex week. No lectures.
Week 7 : 21 October - 27 October	Lecture	What are gravitational waves? How did the Universe become ionised? LIGO, detections of gravitational waves, standard sirens, gravitational wave background, electromagnetic counterparts. Epoch of Reionisation.
Week 8 : 28 October - 3 November	Lecture	How did the Universe start and how will it end? The present-day picture. Expansion of the Universe. Hubble's constant. Precision measurements of Hubble's constant, methods and discrepancies---systematics or new physics? Dark energy. Friedmann equation and metrics.
Week 9 : 4 November - 10 November	Lecture	How did the Universe start and how will it end? Cosmological simulations. The Big Bang nucleosynthesis, horizon and monopole problems. Inflation, galaxy formation, cosmic microwave background and fluctuations. Baryon acoustic oscillations.
Week 10 : 11 November - 17 November	Lecture	What is the future of extragalactic astronomy? Future facilities in extragalactic astronomy. Extragalactic astronomy across wavelengths. Computational tools for studying galaxies and their evolution. The last lecture will include tips in preparation for the final exam.

Attendance Requirements

Students are strongly encouraged to attend all classes and review lecture recordings.

General Schedule Information

Lectures: 1 x 2hr plus 2 x 1hr lectures per week (Weeks 1-10 except Week 6)

Tutorial: 1 hr per week (Weeks 1-10 except Week 6)

Day. Time. Location. Weeks.

Tuesdays 11:00-13:00 OMB150 1-5, 7-10

Thursdays 12:00-14:00 OMB150 1-5, 7-10

Lecture Information

Lecturer: Lectures are taught by Dr Caroline Foster and Dr Nichole Barry. There will be two simultaneous streams for the tutorials.

1. A stream for those new or relatively new to coding. Fundamentals of coding will be explored using astrophysics problems. This stream will be led by Ms Michelle Ding. Room: OMB151
2. A stream appropriate for those who have python or extensive coding experience in another language. The stream will build up to increasingly complex data analysis methods for astrophysical problems. This stream will be developed and led by Mr Roy Lim. Room: OMB150

Students may switch between streams as the course progresses.

Tutorial: Tuesdays 15:00-16:00 in OMB150 and OMB151, Weeks 1-5, 7-10.

Course Resources

Prescribed Resources

The PHYS3116 lecture notes will be posted to Moodle.

Additional resources such as articles, papers, websites, other published material will be referred to during lectures or tutorials and listed at the Moodle site.

Recommended Resources

Recommended resources:

- Carroll, B., & Ostlie, D. (2017). *An Introduction to Modern Astrophysics* (2nd ed.). Cambridge: Cambridge University Press. (Primary, recommended)
  - Print : https://www.bookshop.unsw.edu.au/details.cgi?ITEMNO=9781108422161
  - Digital : https://unswbookshop.vitalsource.com/products/-v9781108390248

Optional resources:

- Ryden, B. (2016). Introduction to Cosmology, 2nd Edition. Cambridge: Cambridge University Press. (Optional)

- Print : https://www.bookshop.unsw.edu.au/details.cgi?ITEMNO=9781107154834
- Digital : https://unswbookshop.vitalsource.com/products/-v9781316889077

- Binney, J., & Merrifield, M. (1999). Galactic Astronomy. Princeton University Press. (Optional)
  - Print : https://www.bookshop.unsw.edu.au/details.cgi?ITEMNO=9780691025650
  - Digital : https://unswbookshop.vitalsource.com/products/-v9780691233321

Course Evaluation and Development

In addition to the usual feedback sought from students at the University level, feedback from students will be welcome throughout the course.

As this is a newly re-developped course with a lot of new content, student feedback will be sought at every lecture via a QR code displayed on the lecture slides linking to this google form. Students may also provide feedback directly to the course convenor via email or after lectures.

Staff Details

Position	Name	Email	Location	Phone	Availability	Equitable Learning Services Contact	Primary Contact
Convenor	Caroline Foster		OMB129		Tuesdays and Thursdays in person. Online on other days.	No	Yes
Administrator	Zofia Krawczyk					No	No
Lecturer	Nichole Barry		OMB126		Mondays and Fridays	No	No
Year coordinator	Elizabeth Angstmann					No	No
Director of teaching	Peter Reece					No	No

Other Useful Information

Academic Information

Upon your enrolment at UNSW, you share responsibility with us for maintaining a safe, harmonious and tolerant University environment.

You are required to:

- Comply with the University's conditions of enrolment.
- Act responsibly, ethically, safely and with integrity.
- Observe standards of equity and respect in dealing with every member of the UNSW community.
- Engage in lawful behaviour.

- Use and care for University resources in a responsible and appropriate manner.
- Maintain the University's reputation and good standing.

For more information, visit the UNSW Student Code of Conduct Website.

Academic Honesty and Plagarism

Referencing is a way of acknowledging the sources of information that you use to research your assignments. You need to provide a reference whenever you draw on someone else's words, ideas or research. Not referencing other people's work can constitute plagiarism.
Further information about referencing styles can be located at https://student.unsw.edu.au/referencing

Academic integrity is fundamental to success at university. Academic integrity can be defined as a commitment to six fundamental values in academic pursuits: honesty, trust, fairness, respect, responsibility and courage. At UNSW, this means that your work must be your own, and others' ideas should be appropriately acknowledged. If you don't follow these rules, plagiarism may be detected in your work.
Further information about academic integrity, plagiarism and the use of AI in assessments can be located at:

- The Current Students site,
- The ELISE training site, and
- The Use of AI for assessments site.

The Student Conduct and Integrity Unit provides further resources to assist you to understand your conduct obligations as a student: https://student.unsw.edu.au/conduct

Submission of Assessment Tasks

Penalty for Late Submissions

UNSW has a standard late submission penalty of:

- 5% per day,
- for all assessments where a penalty applies,
- capped at five days (120 hours) from the assessment deadline, after which a student cannot submit an assessment, and
- no permitted variation.

Any variations to the above will be explicitly stated in the Course Outline for a given course or assessment task.

Students are expected to manage their time to meet deadlines and to request extensions as early as possible before the deadline.

Special Consideration

If circumstances prevent you from attending/completing an assessment task, you must officially apply for special consideration, usually within 3 days of the sitting date/due date. You can apply by logging onto myUNSW and following the link in the My Student Profile Tab. Medical documentation or other documentation explaining your absence must be submitted with your application. Once your application has been assessed, you will be contacted via your student email address to be advised of the official outcome and any actions that need to be taken from there. For more information about special consideration, please visit: https://student.unsw.edu.au/special-consideration

Important note: UNSW has a “fit to sit/submit” rule, which means that if you sit an exam or submit a piece of assessment, you are declaring yourself fit to do so and cannot later apply for Special Consideration. This is to ensure that if you feel unwell or are faced with significant circumstances beyond your control that affect your ability to study, you do not sit an examination or submit an assessment that does not reflect your best performance. Instead, you should apply for Special Consideration as soon as you realise you are not well enough or are otherwise unable to sit or submit an assessment.

Faculty-specific Information

Additional support for students

- The Current Students Gateway
- Student Support
- Academic Skills and Support
- Student Wellbeing, Health and Safety
- Equitable Learning Services
- UNSW IT Service Centre
- Science EDI Student Initiatives, Offerings and Guidelines