

Cosmology

Alexander Knebe (Universidad Autónoma de Madrid)



"THE UNIVERSE IS EXPANDING FASTER THAN EVER, AND
I DON'T EVEN FEEL A BREEZE."

Cosmology

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Cosmology

HOME LECTURES EXERCISES TEACHERS LINKS

← back to Teaching

INFLATION
RECOMBINATION
REIONIZATION
TODAY

10⁻³² Second
380,000 Years
300 Million Years
13.7 Billion Years

Proton
Neutron
Photon
Electron
Helium nucleus
Helium atom
Hydrogen atom
CMB radiation
First stars
Early galaxies
Modern galaxies
HORIZON

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HOME LECTURES EXERCISES **TEACHERS** LINKS

← back to Teaching

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+ help from Santiago Jaraba & Gonzalo Morras

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HOME **LECTURES** EXERCISES TEACHERS LINKS

← back to Teaching

lecture notes:

- [Introduction](#)
- [History & Principles](#)
- [Friedmann-Robertson-Walker Models](#)
- [The Thermal History of the Universe](#)
- [Big Bang Nucleosynthesis](#)
- [Inflation](#)
- [Gauge Invariant Perturbations + Baryogenesis](#)
- [Cosmic Microwave Background Radiation:](#)
 - [observations](#)
 - [theory](#)
- [The Large-Scale Structure of the Universe](#)
- [Cosmic Dawn: The First Stars & Galaxies](#)
- [Observational Cosmology:](#)
 - [the distance ladder](#)
 - [CMB & surveys](#)
- [Gravitational Waves](#)
- [Computational Cosmology](#)
- [Open Problems in Cosmology:](#)
 - [the CDM crisis](#)
 - [alternative gravity](#)

(supplementary notes on [Inflation](#), [GIP](#) and [Baryogenesis](#))

recorded classes:

- [Introduction+Principles](#)
- [History](#)
- [Friedmann-Models-1, Friedmann-Models-2](#)
- [Thermal History](#)
- [Big Bang Nucleosynthesis](#)
- [Inflation](#)
- [GIP+Baryogenesis](#)
- [CMBR I](#)
- [CMBR II](#)
- [LSS-1, LSS-2+CosmicDawn-1](#)
- [CosmicDawn-2+Observations I](#)
- [Observations II](#)
- [GWs](#)
- [OpenProblems](#)

Please check the actual class schedule for 2022/23.

← back to Teaching

PDFs of all Lecture Notes →

lecture notes:

- [Introduction](#)
- [History & Principles](#)
- [Friedmann-Robertson-Walker Models](#)
- [The Thermal History of the Universe](#)
- [Big Bang Nucleosynthesis](#)
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recorded classes:

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- [CMBR I](#)
- [CMBR II](#)
- [LSS-1, LSS-2+CosmicDawn-1](#)
- [CosmicDawn-2+Observations I](#)
- [Observations II](#)
- [GWs](#)
- [OpenProblems](#)

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The screenshot shows a web browser window with the URL <http://popia.ft.uam.es/Cosmology/lectures.html>. The page has a dark red navigation bar with the following menu items: HOME, LECTURES (highlighted with a blue box), EXERCISES, TEACHERS, and LINKS. Below the navigation bar, there is a link for "← back to Teaching".

Two main sections are visible:

- lecture notes:** A list of links to PDFs of all lecture notes, including: Introduction, History & Principles, Friedmann-Robertson-Walker Models, The Thermal History of the Universe, Big Bang Nucleosynthesis, Inflation, Gauge Invariant Perturbations + Baryogenesis, Cosmic Microwave Background Radiation (with sub-items: observations, theory), The Large-Scale Structure of the Universe, Cosmic Dawn: The First Stars & Galaxies, Observational Cosmology (with sub-items: the distance ladder, CMB & surveys), Gravitational Waves, Computational Cosmology, and Open Problems in Cosmology (with sub-items: the CDM crisis, alternative gravity).
- recorded classes:** A list of links to recorded classes from past years, including: Introduction+Principles, History, Friedmann-Models-1, Friedmann-Models-2, Thermal History, Big Bang Nucleosynthesis, Inflation, GIP+Baryogenesis, CMBR I, CMBR II, LSS-1, LSS-2+CosmicDawn-1, CosmicDawn-2+Observations I, Observations II, GWs, and OpenProblems.

At the bottom of the page, there is a note: "(supplementary notes on [Inflation](#), [GIP](#) and [Baryogenesis](#))".

PDFs of all Lecture Notes

recorded classes from past years

Cosmology

<http://popia.ft.uam.es/Cosmology>

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On the left side, under the heading "lecture notes:", there is a list of topics:

- Introduction
- History & Principles
- Friedmann-Robertson-Walker Models
- The Thermal History of the Universe
- Big Bang Nucleosynthesis
- Inflation
- Gauge Invariant Perturbations + Baryogenesis
- Cosmic Microwave Background Radiation:
 - observations
 - theory
- The Large-Scale Structure of the Universe
- Cosmic Dawn: The First Stars & Galaxies
- Observational Cosmology:
 - the distance ladder
 - CMB & surveys
- Gravitational Waves
- Computational Cosmology
- Open Problems in Cosmology:
 - the CDM crisis
 - alternative gravity

At the bottom of this list, there is a note: "(supplementary notes on Inflation, GIP and Baryogenesis)".

On the right side, under the heading "recorded classes:", there is a list of topics:

- Introduction+Principles
- History
- Friedmann-Models-1, Friedmann-Models-2
- Thermal History
- Big Bang Nucleosynthesis
- Inflation
- GIP+Baryogenesis
- CMBR I
- CMBR II
- LSS-1, LSS-2+CosmicDawn-1
- CosmicDawn-2+Observations I
- Observations II
- GWs
- OpenProblems

At the bottom of the page, there is a footer: "Please check the actual class schedule for 2022/23."

PDFs of all Lecture Notes

recorded classes from past years

detailed schedule

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32549 - COSMO 2023/24

day	date	time	teacher	topic	comments
Mon	04/12/2023	16-18	AK	History & Principles	
Tue	05/12/2023	12-14	AK	Friedmann-Robertson-Walker Models	
Mon	11/12/2023	16-18	AK	The Thermal History of the Universe	
Tue	12/12/2023	12-14	AK	Big Bang Nucleosynthesis	
Mon	18/12/2023	16-18	SN	Inflation	
Tue	19/12/2023	12-14	SN	Gauge Invariant Perturbations + Baryogenesis	
---	x-mas break	-----	-----	-----	-----
Mon	08/01/2024	16-18	AK+SN+GM+SJ	DISCUSSION EXERCISES #1	submission Thu, 20/12/2023
Tue	09/01/2024	12-14	AK	The Cosmic Microwave Background Radiation I	
Mon	15/01/2024	16-18	SN	The Cosmic Microwave Background Radiation II	
Tue	16/01/2024	12-14	AK	The Large-Scale Structure of the Universe	
Mon	22/01/2024	16-18	AK+SN+GM+SJ	DISCUSSION EXERCISES #2	submission Thu, 18/01/2024
Tue	23/01/2024	12-14	AK	Cosmic Dawn: The First Stars & Galaxies	
Mon	29/01/2024	-----	-----	-----	
Tue	30/01/2024	12-14	AK	Observational Cosmology I: the distance ladder	
Mon	05/02/2024	16-18	AK+SN+GM+SJ	DISCUSSION EXERCISES #3	submission Thu, 01/02/2024
Tue	06/02/2024	12-14	SN	Observational Cosmology II: CMB & LSS & surveys	
Mon	12/02/2024	16-18	SN	Gravitational Waves	
Tue	13/02/2024	12-14	AK	Computational Cosmology	
Mon	19/02/2024	16-18	AK+SN+GM+SJ	DISCUSSION EXERCISES #4	submission Thu, 15/02/2024
Tue	20/02/2024	12-14	SN	Open Problems	
Mon	26/02/2024	-----	-----	-----	
Tue	27/02/2024	-----	-----	-----	
Mon	04/03/2024	09:30h-13:00h	AK+SN	written exam	
teachers: Alexander Knebe (AK, UAM, coordinator), Savvas Nesseris (SN, IFT/Profesor Honorario UAM, coordinator) Santiago Jaraba (SJ, PhD student UAM) Gonzalo Morras (GM, PhD student UAM)					

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Tue	13/02/2024	12-14	AK	Computational Cosmology	
Mon	19/02/2024	16-18	AK+SN+GM+SJ	DISCUSSION EXERCISES #4	submission Thu, 15/02/2024
Tue	20/02/2024	12-14	SN	Open Problems	
Mon	26/02/2024	-----	-----	-----	
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Translation Available

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Cosmology

HOME LECTURES **EXERCISES** TEACHERS LINKS

← back to Teaching

	<u>return</u>	<u>discussion</u>
• exercises #1	Thu, 20/12/2023	Mo, 08/01/2024
• exercises #2	Thu, 18/01/2024	Mo, 30/01/2024
• exercises #3	Thu, 01/02/2024	Mo, 13/02/2024
• exercises #4	Thu, 15/02/2024	Mo, 27/02/2024

← back to Teaching

exercise sheets

- [exercises #1](#)
- [exercises #2](#)
- [exercises #3](#)
- [exercises #4](#)

	<u>return</u>	<u>discussion</u>
	Thu, 20/12/2023	Mo, 08/01/2024
	Thu, 18/01/2024	Mo, 30/01/2024
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The screenshot shows a web browser window with the URL popia.ft.uam.es/Cosmology/exercises.html. The page title is "Cosmology". A navigation bar contains links for HOME, LECTURES, EXERCISES (highlighted with a blue box), TEACHERS, and LINKS. Below the navigation bar, there is a link "← back to Teaching". A list of exercise sheets is shown:

• exercises #1	<u>return</u>	<u>discussion</u>
• exercises #2	Thu, 20/12/2023	Mo, 08/01/2024
• exercises #3	Thu, 18/01/2024	Mo, 30/01/2024
• exercises #3	Thu, 01/02/2024	Mo, 13/02/2024
• exercises #4	Thu, 15/02/2024	Mo, 27/02/2024

Below the list, the section "exercise flavours:" is detailed:

- Part A:
 - solving a given problem
 - written solution to be handed in (and marked by teacher)
- Part B:
 - conceptual questions
 - be prepared to lead discussion in class

exercise sheets

← back to Teaching

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← back to Teaching

exercise sheets

- [exercises #1](#)
- [exercises #2](#)
- [exercises #3](#)
- [exercises #4](#)

	<u>return</u>	<u>discussion</u>
	Thu, 20/12/2023	Mo, 08/01/2024
	Thu, 18/01/2024	Mo, 30/01/2024
	Thu, 01/02/2024	Mo, 13/02/2024
	Thu, 15/02/2024	Mo, 27/02/2024

exercise solutions:

- work in team of 2 - (max.) 3 students
- hand-in solutions as team (all get same mark)
- return a PDF with solutions to Part A via email:
 - a scanned version* or
 - typeset right from the start (preferred)
- plagiarism will have consequences

*unreadable solutions will not be marked!

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exercise sheets

	<u>return</u>	<u>discussion</u>
• exercises #1	Thu, 20/12/2023	Mo, 08/01/2024
• exercises #2	Thu, 18/01/2024	Mo, 30/01/2024
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• exercises #4	Thu, 15/02/2024	Mo, 27/02/2024

exercise discussion:

- Part A exercises will be presented by a student
- Part B exercises will be discussed in class, but discussion will be led by a student...
- students will be picked “randomly” by teacher(s)

← back to Teaching

exercise sheets

- [exercises #1](#)
- [exercises #2](#)
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	<u>return</u>	<u>discussion</u>
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final mark:

- exercises (marked solutions): 50%
- final exam (3 hours): 50%

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exercise sheets

- [exercises #1](#)
- [exercises #2](#)
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	<u>return</u>	<u>discussion</u>
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- exercises (marked solutions): 50%
- final exam (3 hours): 50%

**at least 50%
in each category
to pass course**

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final mark:

- exercises (marked solutions): 50%
- **final exam** (3 hours): 50%

▪ *also features part A and B*

▪ *books and lecture notes are allowed only in ordinary call*

**at least 50%
in each category
to pass course**

exercise sheets



← back to Teaching

exercise sheets

	<u>return</u>	<u>discussion</u>
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convocatoria extraordinaria:

- exercise marks will be lost
- written 4-hour exam without any help

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HOME LECTURES EXERCISES TEACHERS **LINKS**

← back to Teaching

Books

- "Modern Cosmology", Scott Dodelson
- "Cosmology", Coles & Lucchin
- "Cosmological Physics", John A Peacock
- "Cosmological Inflation & Large-Scale Structure", Andrew R Liddle
- "Modern Cosmology", Andrew R Liddle

annotated notes created by students* from 2020/21

- Cosmological Principles
- FRWmodels
- Thermal History of the Universe
- Big Bang Nucleosynthesis
- Inflation
- Gauge Invariant Perturbations
- Baryogenesis
- Cosmic Microwave Background Radiation
- Large-Scale Structure of the Universe
- Cosmic Dawn
- Observational Cosmology
- GravitationalWaves
- Open Problems in Cosmology

*Sara Ortega Martínez & M. Alejandra Díaz Teodori

UAM

The official "Guia Docente" (course syllabus) can be found [here](#).

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- GravitationalWaves
- Open Problems in Cosmology

*Sara Ortega Martínez & M. Alejandra Díaz Teodori

recommended textbooks:

- Coles & Lucchin: "Cosmology"
- Dodelson: "Modern Cosmology"

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created by previous students in preparation of final exam

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