ASTR 610
Theory of Galaxy Formation

Lecture 1

Frank van den Bosch

Yale University, Spring 2024

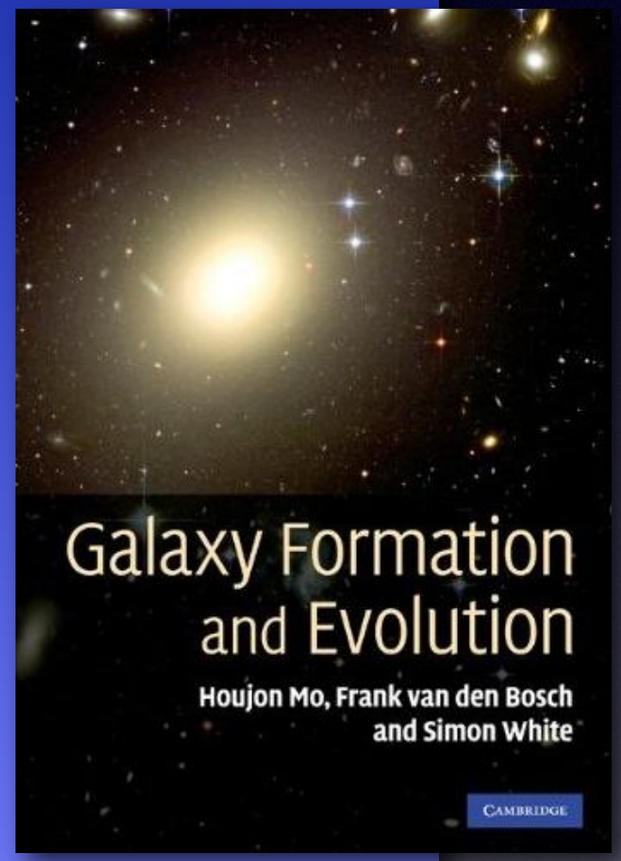
Important Information

Instructor: Prof. Frank van den Bosch (Office: 52HH#320)
frank.vandenbosch@yale.edu

Course Website: http:/campuspress.yale.edu/astro610/

Lecture Hours: Mon-Wed 9.00-10.15am [KT 221]

Textbook: Galaxy Formation & Evolution
Mo, van den Bosch & White (hereafter MBW)
http://www.astro.yale.edu/vdbosch/book.html



Syllabus: available on course website & canvas

Lecture Notes: will be made available on course website

Grading: 40% Final Exam (oral)
30% Term Paper & Presentation (topic picked in class)
30% Problem Sets

The Course

Format: 24 lectures (see preliminary schedule)
2 classes with student presentations (week 14)

Requirements:

graduate student in physics or astronomy
familiarity with astronomy nomenclature (magn, Mpc, H_0)
basic knowledge of extra-galactic astronomy
(read chapter 2 of MBW)

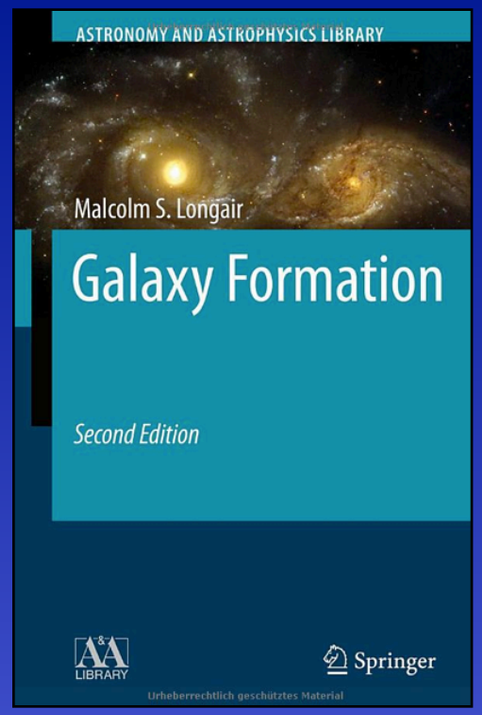
My goal for you:

to teach you the physics related to galaxy formation
to teach you basic concepts & relevant nomenclature
to prepare you for research in extra-galactic astrophysics

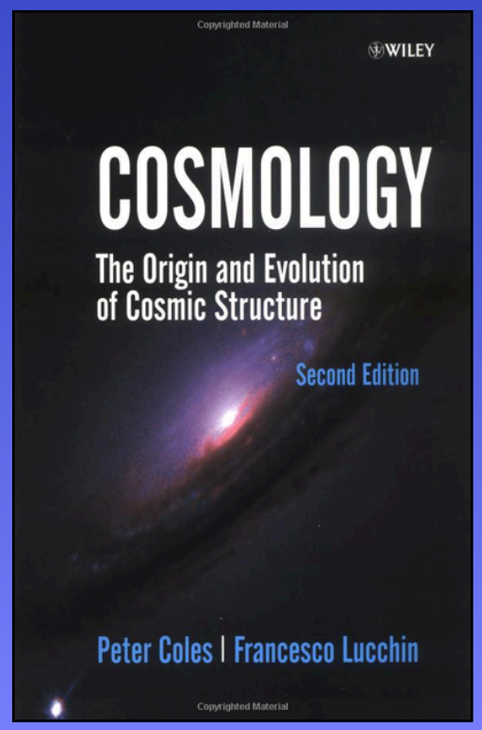
What I expect from you:

participate actively in class (ask questions)
hand in problem sets on time
term paper (±8-10 pages on topic of current interest)
presentation in class (=online) on term paper
oral exam (1 hour, during exam period)

Additional Recommended Textbooks

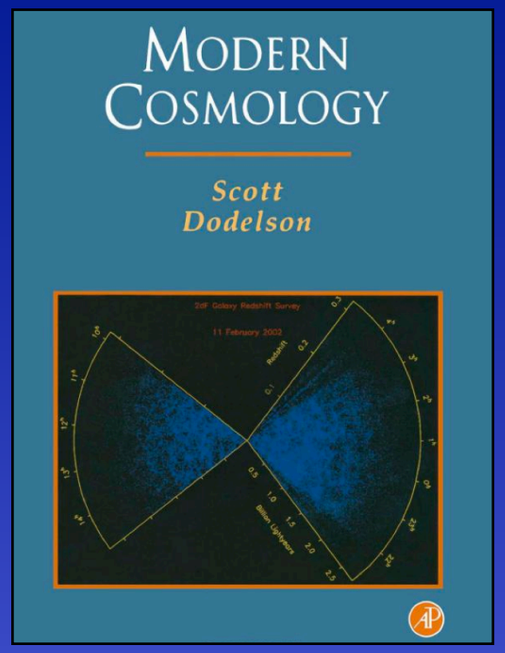


Good additional source of information.
Somewhat less advanced than MBW.
Does not cover the gastrophysical processes of galaxy formation (cooling, star formation feedback) in any detail.

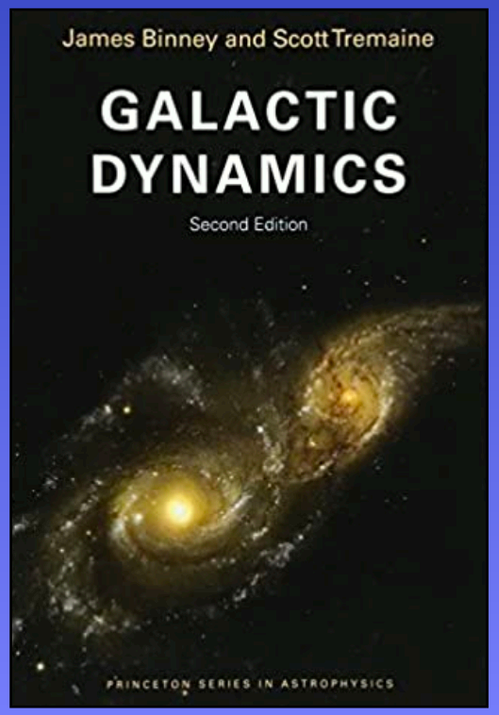


One of the best graduate textbooks on cosmology.
Excellent coverage of Newtonian perturbation theory. Does not cover galaxy formation in any detail, though...

Additional Recommended Textbooks

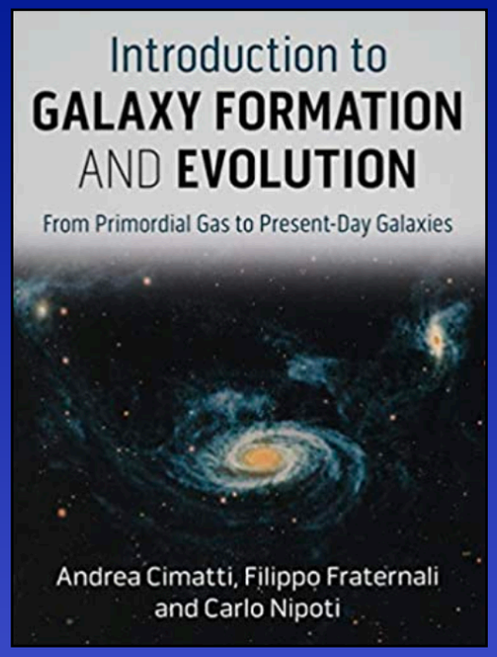


Detailed coverage of structure formation in the linear regime with superb treatment of relativistic perturbation theory.
Nice chapter on likelihood analysis.
Does not cover non-linear collapse, or galaxy formation.



A classic! Excellent textbook on dynamics.
Has detailed information on equilibria, collisions and interactions of collisionless systems.

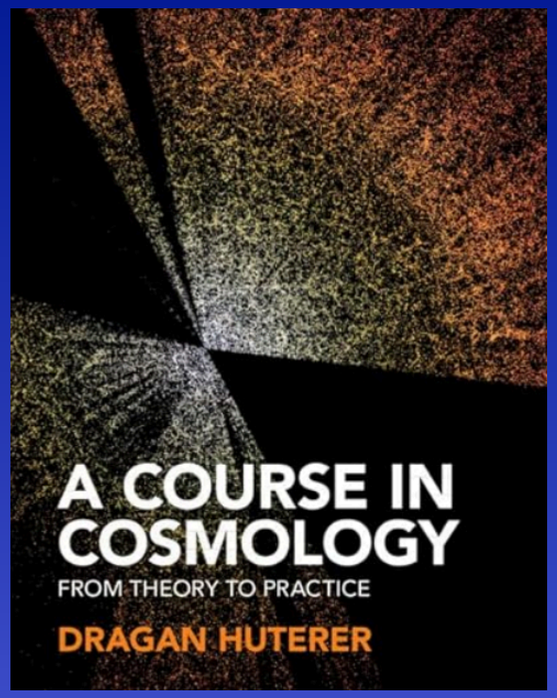
Additional Recommended Textbooks



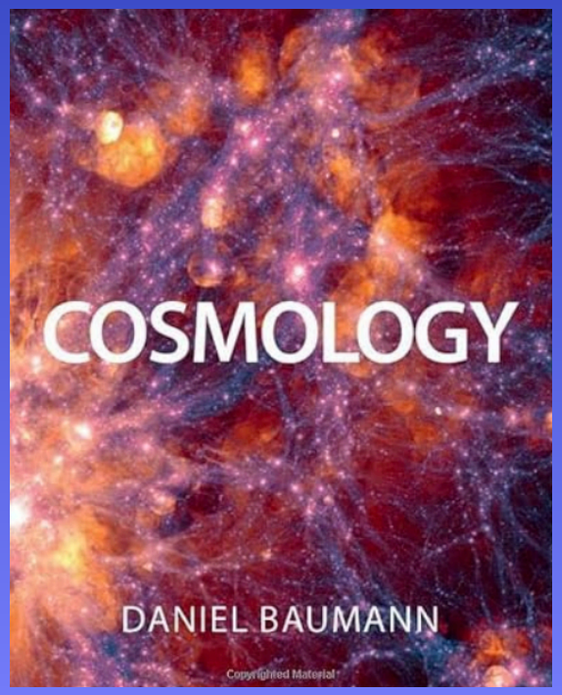
Fairly new…an undergraduate companion to MBW.
Excellent additional source of information,
and very much up to date.

Good companion for MBW, with detailed treatment of reionization, first stars and 21cm cosmology.

Additional Recommended Textbooks



Excellent, brand new book on cosmology with detailed treatment of structure formation and large scale structure (including data analysis techniques)



Another fairly new and excellent book on cosmology and structure formation.

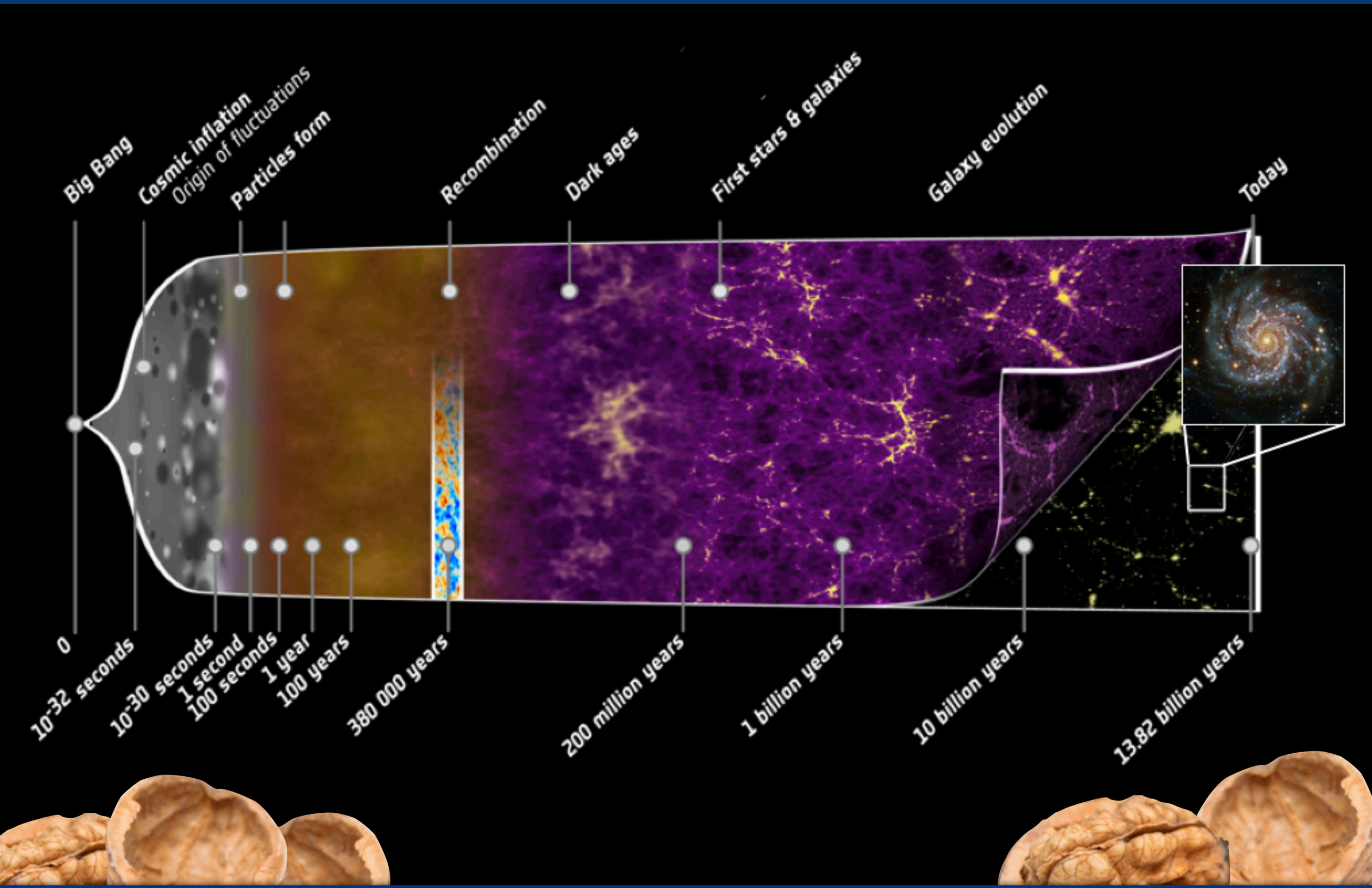
Preliminary Schedule

week	Date	Topic	MBW
1	Wed 01/17	Introduction; A Broad Brush Overview of Galaxy Formation	chapter 1
1	Fri 01/19	Cosmology (Riemannian geometry, FRW metric, cosmological distances)	§3.1
2	Mon 01/22	Relativistic Cosmology (GR, Friedmann eqs)	§3.2
2	Wed 01/24	Newtonian Perturbation Theory: linearized fluid equations	§4.1
3	Mon 01/29	Newtonian Perturbation Theory: baryonic perturbations	§4.1
3	Wed 01/31	Newtonian Perturbation Theory: dark matter	§4.1
4	Mon 02/05	Transfer Function and the Cosmic Microwave Background	§4.3 - §6.7
4	Wed 02/07	Non-linear collapse and Relaxation	chapter 5
5	Mon 02/12	Press-Schechter Theory, Excursion Set Formalism and Halo Mass Function	§7.2
5	Wed 02/14	Merger Trees and Halo Bias	§6.1 - §6.2 - §6.5
6	Mon 02/19	Structure of Dark Matter Halos	§7.3 - §7.4
6	Wed 02/21	Large Scale Structure	§6.1 - §6.2 - §6.5
7	Mon 02/26	Halo Model and Halo Occupation Statistics	§7.6 - §15.6
7	Wed 02/28	Galaxy Interactions & Transformations	chapter 12
8	Mon 03/04	Cooling Processes & Photo-Ionization Heating	§8.1 - §8.3 - §8.4
8	Wed 03/06	Review of material covered so far [in class discussion]	

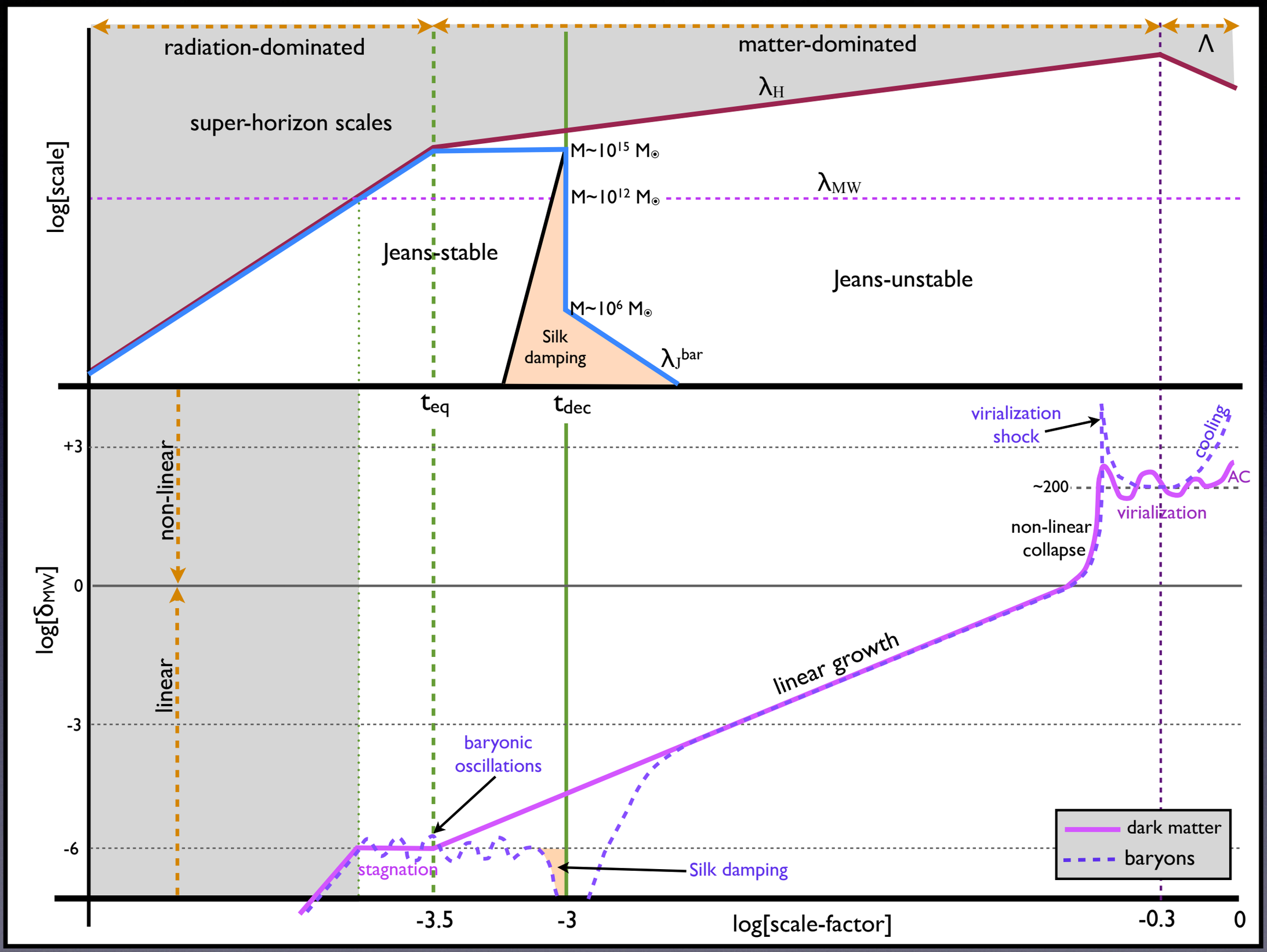
Preliminary Schedule

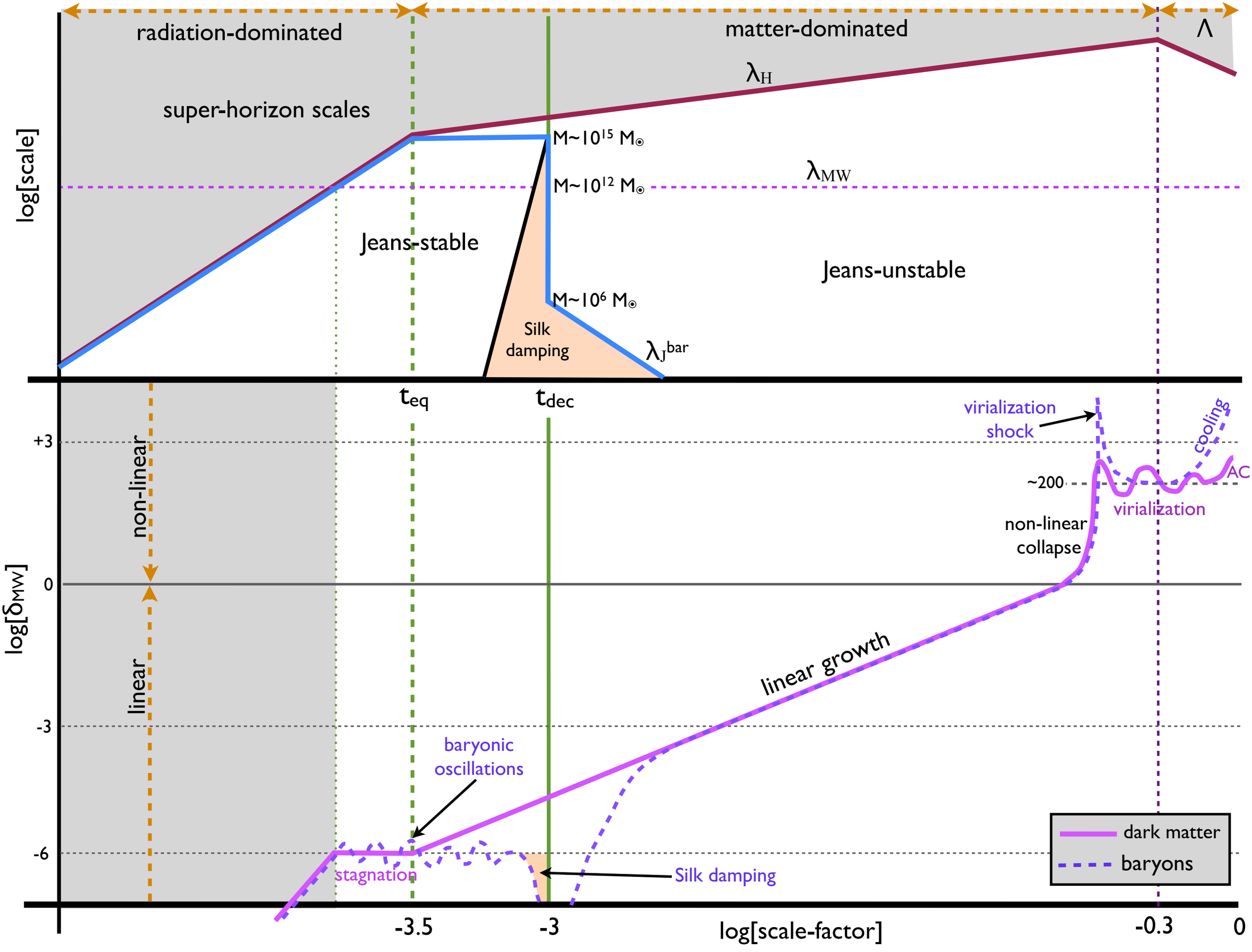
9	Mon 03/11	NO CLASS: Spring Break	
9	Wed 03/13	NO CLASS: Spring Break	
10	Mon 03/18	NO CLASS: Spring Break	
10	Wed 03/20	NO CLASS: Spring Break	
11	Mon 03/25	Star Formation	§9.1 - §9.3 - §9.5
11	Wed 03/27	Supernova Feedback	§8.6 - §10.5
12	Mon 04/01	Structure and Formation of Disk Galaxies	chapter 11
12	Wed 04/03	Structure and Formation of Elliptical Galaxies	chapter 13
13	Mon 04/08	AGN and supermassive black holes	chapter 14
13	Wed 04/10	Numerical Simulations	App C
14	Mon 04/15	Outstanding Issues in Galaxy Formation I	
14	Wed 04/17	Outstanding Issues in Galaxy Formation II	
15	Mon 04/22	Student Presentations	
15	Wed 04/24	Student Presentations	

Galaxy Formation in a Nutshell



Galaxy Formation in a Nutshell




radiation-dominated
matter-dominated
Λ
super-horizon scales
λH
log[scale]
M~10^15 M⊙
λMW
M~10^12 M⊙
Jeans-stable
Jeans-unstable
M~10^6 M⊙
Silk
damping
λJbar
teq
tdec
virialization
shock
cooling
+3
~200
AC
virialization
non-linear
collapse
non-linear
linear
0
-3
-6
log[δMW]
linear growth
baryonic
oscillations
stagnation
Silk damping
dark matter
baryons
-3.5
-3
log[scale-factor]
-0.3
0