Cosmological structure formation: theory and observations

1 Course plan

1– 3 Introduction to the structured universe, observables and statistical tools (3 lectures).
Introduction to the structured Universe. Current state of observations: cosmological backgrounds, photometric and spectroscopic surveys (weak lensing, SN, clusters, types of galaxies, absorption/emission lines, BAO), CMB experiments. Statistical tools: 3D and angular correlation functions, power spectra, luminosity functions, number counts (definitions and properties, examples of their calculation for simple cases, relations between them). Re-definitions of distances in FRW models.

4–6 Structure formation in the standard model: linear regime (3 lectures).
Overview of theory of structure formation; physics of linear fluctuations (Newtonian derivation) in expanding universe, outline of essential full GR treatment (gauges, gauge-invariant formalism), transfer function for 3D DM power spectrum, theory of CMB fluctuations (of temperature and polarisation); baryon acoustic oscillations in CMB and galaxies; weak lensing in the linear regime.

7–8 Structure formation in the standard model: non-linear regime (2 lectures).
The breakdown of linear theory; some analytic approaches beyond linear theory: spherical collapse and PS formalism; N-body simulations, self-similarity, stable clustering and PD formalism, halo models.

9–10 Galaxy formation and other hot topics (2 lectures).
Bias, galaxies and clusters (link between dark and visible matter): theory of galaxy formation, and phenomenology of gastrophysics. Detection of dark matter. Dark energy and structure formation. Reionization.

2 Contacts

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3 Textbooks

• *Modern Cosmology*, S. Dodelson. Academic Press (Elsevier), 2003.

• *Galaxy Formation and Evolution*, H. Mo, F. van den Bosch, S. White, Cambridge, 2011.

• *Extragalactic Astrophysics and Cosmology: An Introduction*, P. Schneider, Springer, 2006.

• *Galaxy Formation*, M. S. Longair. Springer, 2008.

• *Cosmological Physics*, J. A. Peacock. Cambridge University Press, 1998.

• *Structure Formation in the Universe*, T. Padmanabhan, Cambridge University Press, 1993.

4 Practical Information

Lecture time: **Monday afternoon from 2 to 5:15 pm**

Place: First lecture and lectures 1-3 in Orsay (LAL, room 101); lectures 4 - 10 in Paris, Jussieu, room 1213-RDC-11.

Attention: 3rd class will be held on an unsual date: Thu Jan 26th at 9am.

Please make sure the lecturers have your email address so that you receive information about the course during the semester.

5 Evaluation

The end of semester exam will consist in two parts:

- a written exam based on the whole course (1h30 to 2 hours);
- an individual oral exam (30 minutes) consisting of general questions on the course, followed by an informal blackboard presentation/discussion of a chosen article (a list of suggested articles will be distributed in the middle of the semester).

6 Other relevant textbooks

• *Principles of Physical Cosmology*, P. J. E. Peebles. Princeton University Press, 1993.

• *The Large Scale Structure of the Universe*, P. J. E. Peebles. Princeton University Press, 1980.

• *Observational Cosmology*, S. Serjeant, Cambridge, 2010.

• *Cosmological inflation and large scale structure*, A. R. Liddle & D. H. Lyth. Cambridge University Press, 2000.

• *Physical Foundations of Cosmology*, V. Mukhanov, Cambridge University Press, 2005.

• *Fundamentals of Cosmology*, J. Rich, Springer, 2002 (v.f. : *Principes de la cosmologie*, Editions de l'Ecole Polytechnique, 2002).

• *Cosmologie Primordiale*, P. Peter & J.P. Uzan, Belin, 2005.

• *Cosmology and Controversy*, H. Kragh, Princeton University Press, 1996. (History of cosmology 1915-1971)