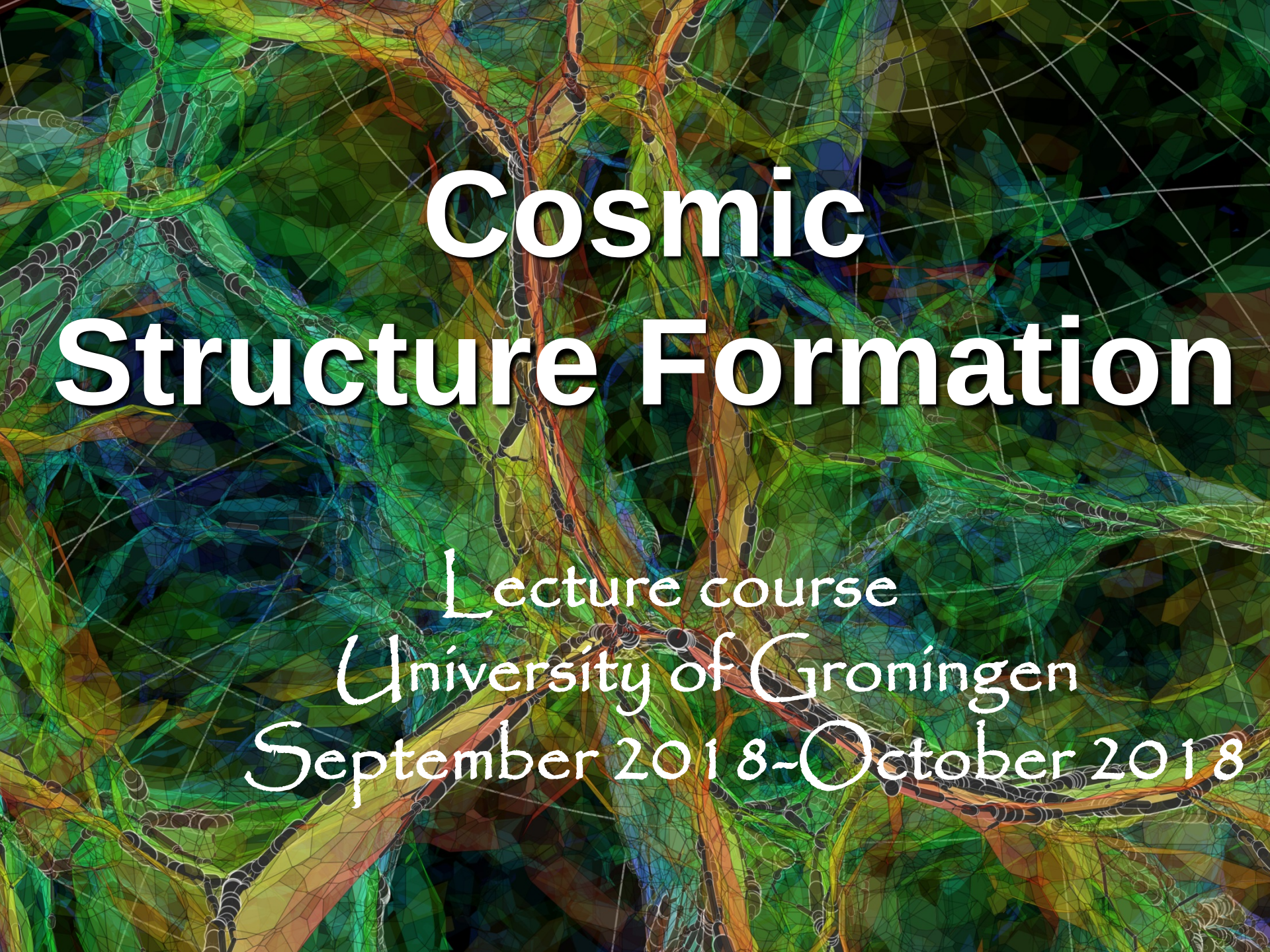

Cosmic
Structure Formation
Lecture course
University of Groningen
September 2018-October 2018

Practical Matters

Lectures: Kapteynborg

tuesday	15:00-17:00	Kapteynborg 5419 - 237
friday	13:00-15:00	Kapteynborg 5419 – 237/230/ 105/103
friday	15:00-17:00	Kapteynborg 5419 - 161

Lectures: Rien van de Weygaert
rm. 186; tel. 050-3634086;
weygaert@astro.rug.nl

Tutorials: Olmo Piana
rm. 185; tel. 050-3638689
piana@astro.rug.nl

Website: www.astro.rug.nl/~weygaert/lss2018.html

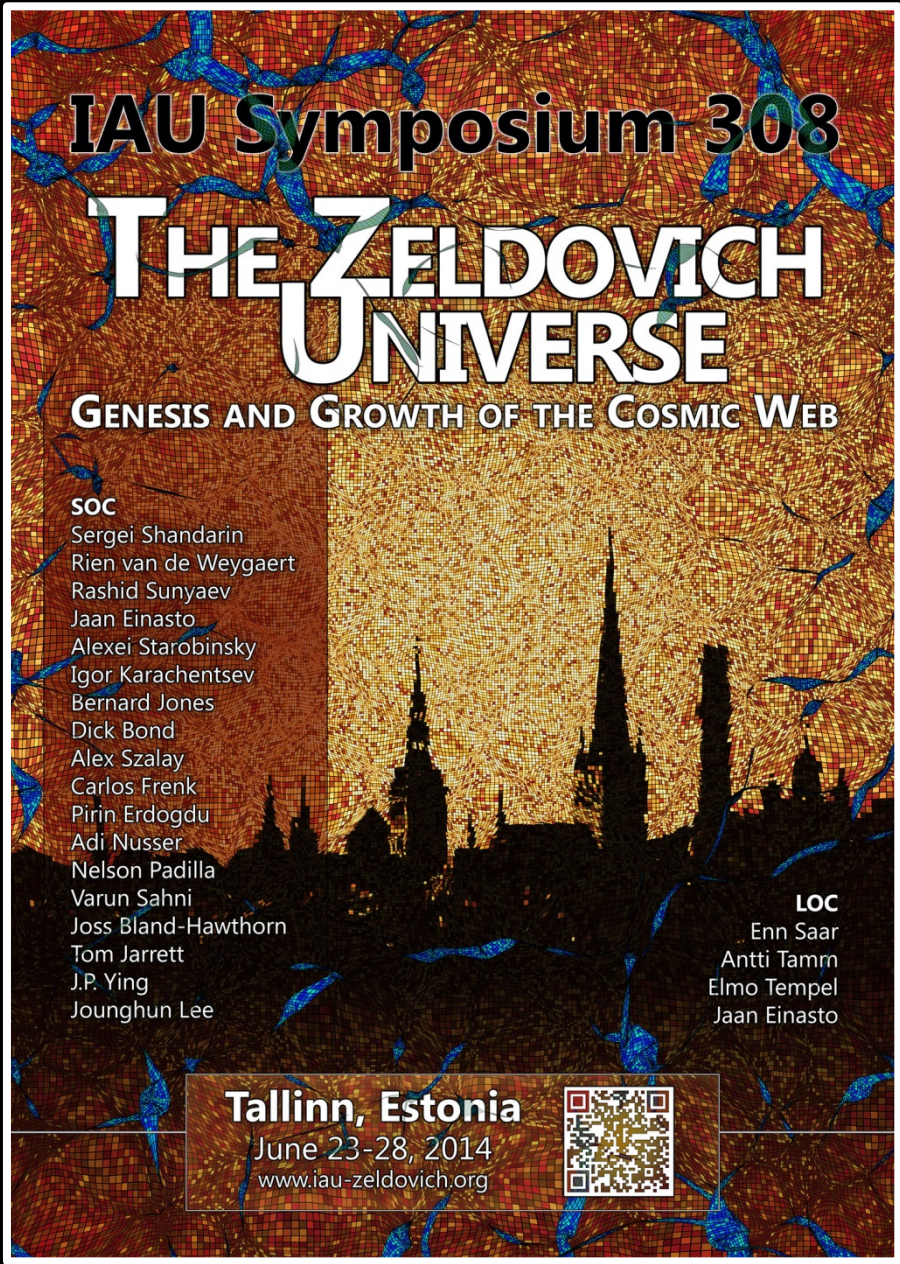
Lecture Room Schedule

Lectures Rooms:

tuesday	15:00-17:00	Kapteynborg 5419 – 237
friday	13:00-15:00	
Sept. 7		Kapteynborg 5419 - 237
Sept. 14		Kapteynborg 5419 - 105
Sept. 21		Kapteynborg 5419 - 105
Sept. 28		Kapteynborg 5419 - 105
Oct. 5		Kapteynborg 5419 - 230
Oct. 12		Kapteynborg 5419 - 103
Oct. 19		Kapteynborg 5419 - 105
Oct. 26		Kapteynborg 5419 - 237
friday	15:00-17:00	Kapteynborg 5419 – 161

Exam: wed. Oct. 31 14:00-17:00 Kapteynborg 5419 - 161


Lorentz center
Tracing the Cosmic Web
Workshop: 17 - 21 February 2014, Leiden, the Netherlands
Scientific Organizers
• Noam Libeskind, AIP Potsdam
• Rien van de Weygaert, U Groningen
Scientific Organizing Committee
• Yehuda Hoffman, HUJI Jerusalem
• Fransisco Kitaura, AIP Potsdam
• Sergei Shandarin, KU Lawrence
• Thierry Sousbie, IAP Paris
• Elmo Tempel, U Tartu
Topics
• Large-Scale Distribution of Matter and Galaxies
• Voids, Sheets, Filaments and Clusters
• Geometry, Topology and Multiscale Structure
• Dynamics and Evolution of the Cosmic Web
• Techniques for Characterizing Weblike Patterns
• Galaxy Formation and the Cosmic Web
The Lorentz Center is an international center in the sciences. Its aim is to organize workshops for scientists in an atmosphere that fosters collaborative work, discussions and interactions.
For registration see: www.lorentzcenter.nl
Galaxies, intergalactic gas and dark matter aggregate in a complex network, known as the 'cosmic web'. Image: R. Kaehler, O. Hahn, T. Abel. Processing: N. Bos
Poster design: SuperNova Studios, NL
FOM
STW
NWO
Lorentz center
www.lorentzcenter.nl


IAU Symposium 308
The Zeldovich Universe
Genesis and Growth of the Cosmic Web
SOC
Sergei Shandarin
Rien van de Weygaert
Rashid Sunyaev
Jaan Einasto
Alexei Starobinsky
Igor Karachentsev
Bernard Jones
Dick Bond
Alex Szalay
Carlos Frenk
Pirin Erdogdu
Adi Nusser
Nelson Padilla
Varun Sahni
Joss Bland-Hawthorn
Tom Jarrett
J.P. Ying
Jounghun Lee
LOC
Enn Saar
Antti Tamm
Elmo Tempel
Jaan Einasto
Tallinn, Estonia
June 23-28, 2014
www.iau-zeldovich.org

Exam

Three Constituents:

1.	Exam (written)	65%	wed. Oct 31
2.1	Tutorial Assignments (mandatory)	15%	
2.2	Computer Assignments	20%	

Correlation Function, CMB Dipole,

Gaussian Fields, Zeldovich …

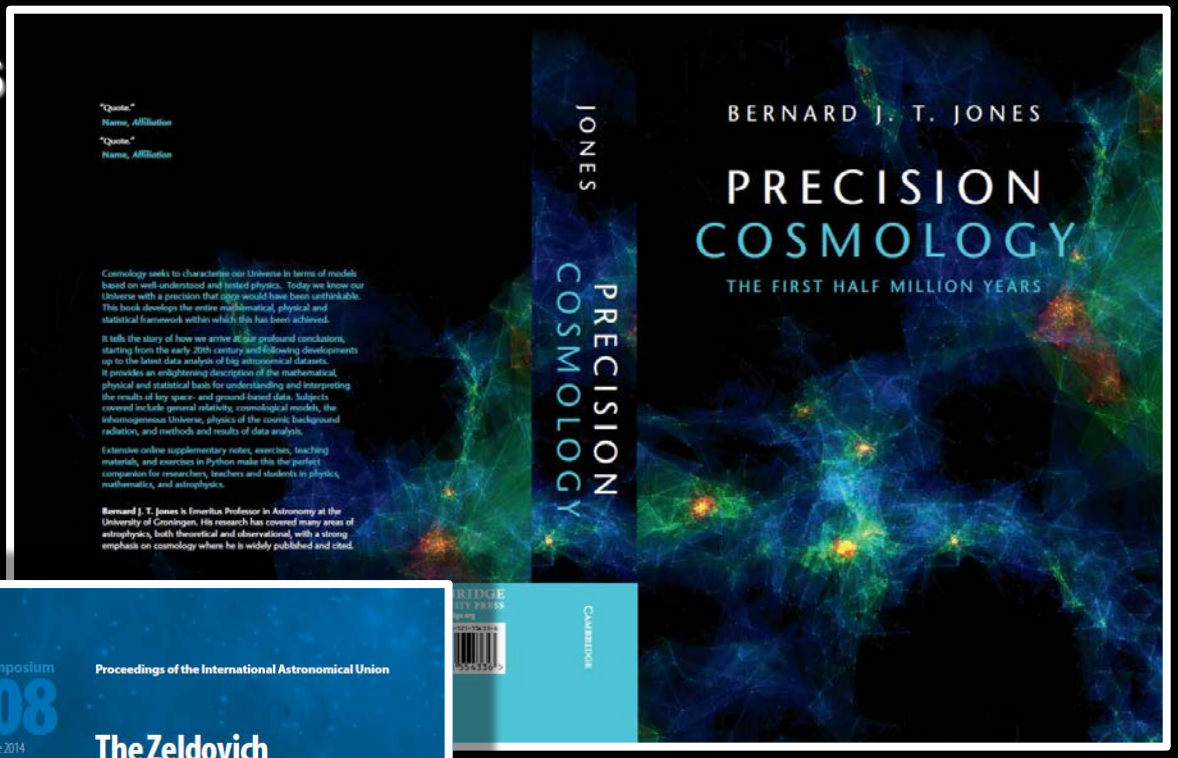
Literature

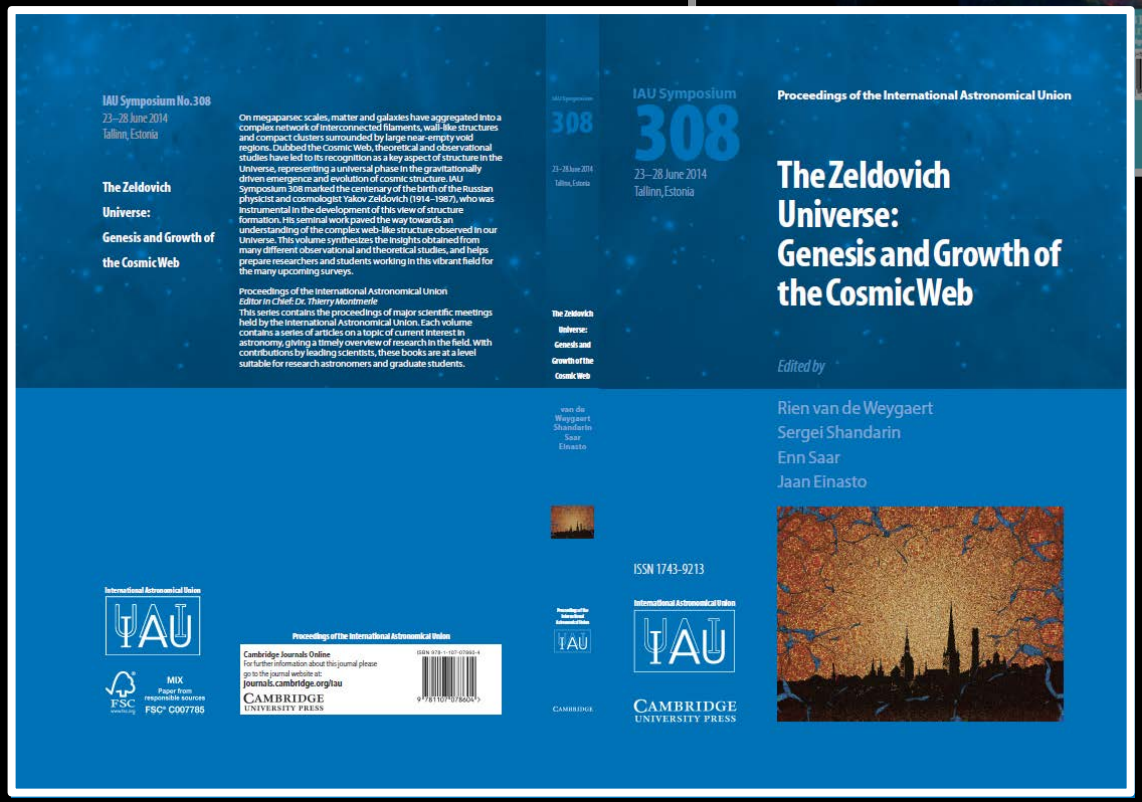
- **Large Scale Structure of the Universe**
  P.J.E. Peebles, Princeton Univ. Press, 1981
  The Classic Book, the Bible … defining the field !!!!!!!!!!!!
- **Galaxy Formation**
  M. Longair; Springer, A&A Library, 2nd ed., 2008
  Good overview of structure and galaxy formation
- **Galaxy Formation and Evolution**
  H.J. Mo, F. van den Bosch, S.D.M. White, Cambridge Univ. Press, 2010
  Most up to date book on cosmic structure formation
- **Structure Formation in the Universe**
  T. Padmanabhan, Cambridge Univ. Press, 1993
  very thorough, advanced level: hard to work through
- **Cosmology**
  S. Weinberg; Oxford Univ. Press, 2008
  Impressive book, covering most of relevant cosmological topics, including structure formation, inflation theory, origin perturbations, CMB
- **Cosmological Physics**
  J. Peacock; Cambridge Univ. Press, 1998
  very thorough treatment of relevant topics, advanced level
- **Statistics of the Galaxy Distribution**
  V.J. Martinez & E. Saar; Chapman & Hall/CRC, 2001
  best book on statistical analysis of galaxy distribution; treats fundamentals, little bit outdated

Groningen Books

The Zeldovich Universe:
Genesis and Growth of the Cosmic Web
Proc. IAU Symposium 308

R. van de Weygaert et al., eds.
Cambridge Univ. Press, £80.00
Nov. 30, 2016





Precision Cosmology
the first half million years

B.J.T. Jones
Cambridge Univ. Press, £64.99
Mar. 31, 2017

Literature

- A Pan-Chromatic View of Clusters of Galaxies and the Large-Scale Structure
  M. Plionis, O. Lopez-Cruz, D. Hughes, eds., Lect. Notes in Physics 720, Springer, 2008
  Very useful reviews on in particular cluster physics.
  Two chapters part of course material (Van de Weygaert & Bond 2008a, 2008b)

- The Zeldovich Universe: Genesis and Growth of the Cosmic Web
  R. van de Weygaert, et al., Cambridge Univ. Press, Nov. 2016
  proceedings IAU Symp. 308, Tallinn, 2014
  nice collection of state-of-the-art papers on cosmic structure formation

- How did the First Stars and Galaxies Form
  A. Loeb, Princeton Univ. Press, 2010
  beautiful expose on the first stages of structure and galaxy formation

- the Cosmic Microwave Background
  R. Durrer, Cambridge Univ. Press, 2008
  best textbook on the physics of the CMB

- Introduction to Cosmology
  B. Ryden, Addison-Wesley, 2003
  good reference book on basic cosmology

- Precision Cosmology
  B.J.T. Jones, Cambridge Univ. Press, 2017
  perfect advance level textbook cosmology

Lecture Schedule:

(provisional, changes possible)

Week	Dates Hoorcollege	Subject Hoorcollege	Dates Werkcollege	Subject Werkcollege
1	September 4 (c) September 7 (c)	Introduction: Cosmic Inventory: Large Scale Structure & Cosmic Structure Formation Galaxies, Groups, Clusters, Superclusters, IGM Cosmic Structure Formation Primordial Fluctuations & the Cosmic Microwave Background Basic Cosmology: Einstein Field Equation, Cosmological Principle, Robertson-Walker metric, Redshift, Cosmic Distances Friedman Equations Cosmic Epochs	September 7 (w)	FRW Cosmology FRW universe solutions Observational Cosmology

2	September 11 (c) September 14 (c)	Gravitational Instability: (Linear) Perturbation Theory, Structure Growth Cosmic Components & Influence on Cosmic Structure Formation: Radiation, Matter: Baryonic Matter & Dark Matter Dark Energy Cosmic Flows	September 14 (w)	Perturbation Theory Growth Factors
3	September 18 (c) September 22 (c)	Random Density & Velocity Fields Multidimensional Gaussian distributions Filtering Power Spectrum Random Fields & Power Spectrum Nonlinear Clustering & Structure Formation Hierarchical Clustering, Anisotropic Collapse and the Formation of Voids Spherical Model, Ellipsoidal Model	September 22 (w)	Perturbation Theory Growth Factors
4	September 25 (c) September 28 (c)	Lagrangian Perturbation Theory Zel'dovich formalism Adhesion approximation Phase Space Dynamics Phase Space Sheet Matter Scales Jeans Mass, Silk damping Cosmic Scenarios: Power spectra Cold Dark Matter, Hot Dark Matter	September 28(w)	Spherical Collapse & Model

		non-Gaussian perturbations		
5	October 2 (c) October 5 (c)	Mapping the Universe Galaxy sky surveys Galaxy redshift Surveys Lensing Surveys The Cosmic Web Observed Cosmic Web: Filaments, Sheets and Voids Clusters of Galaxies	October 5 (w)	Power Spectrum & Spherical Model
6	October 9 (c) October 12 (c)	Analysis of the Large Scale Structure Correlation functions Counts in Cells Power spectrum Higher-order statistics Topology: Genus, Minkowski functionals, Betti numbers Cosmic Web Analysis Tessellation Analysis, DTFE, Phase Space Sheet Multiscale Morphology Filter Watershed (Void Finder) Morse Theory, Skeleton \& Cosmic Spine	October 12 (w)	Two-point correlation function (computer task)
7	October 16 (c)	Hierarchical clustering: Press-Schechter and Excursion set formalism Peak-patch formalism Cosmic Tidal Fields & Cosmic Web Theory Virialization Cooling and Galaxy Formation Halo Model	October 19 (w)	Press-Schechter Formalism & Halo Mass Functions

	October 19 (c)	**Biasing** **Nonlinear Structure Formation: N-body models** **N-body simulation techniques** **Cosmological Hydro simulation techniques** **Cosmological Computer Simulations:** **Cluster Simulations** **Large Scale Structure simulations**		
8	**October 23 (c)** **October 26 (c)**	**Intergalactic Medium: Lya forest & WHIM** **Gravitational Lensing, Cosmic Shear** **Dark Ages, First Stars & Reionization** **Cosmic Microwave Background Anisotropies** **CMB anisotropies, temperature perturbations** **CMB anisotropies, experiments & satellites** **CMB anisotropies, analysis & maps** **CMB anisotropies, secondary perturbations** **CMB anisotropies, polarization**	**October 26 (w)**	**N-body Simulations** **(computer task)**

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