Advanced Cosmology

L. Amendola and C. Heneka
SS 2025
University of Heidelberg

with help from
Guillem Domenech, Oliver Piattella, Ziyang Zheng

Thanks to C.Pfrommer for some of his slides

Contacts

l.amendola@thphys.uni-heidelberg.de
Inst. Theor. Physics, Philosophenweg 16, room 26
heneka@thphys.uni-heidelberg.de
Inst. Theor. Physics, Philosophenweg 12, room 306

Course material and information:
https://www.thphys.uni-heidelberg.de/~amendola/advcosm-ss2025.html

Goals

- Learn about current cosmological research
- **Educate** your classmates
- Develop scientific presentations **skills** and improve public **speaking** (in English!)
- Learn how to **learn** quickly and effectively **read** scientific literature
- Become comfortable **discussing** science given only a ‘shallow’ understanding

Format of the seminars

- We have compiled a list of several cosmology topics
- Work in pairs and jointly present a given topic
- Each person should plan to speak for 25 minutes, and expect about 5 minutes of questions

Topics

-1. Supernovae and cosmology
- 2. Cold Dark Matter and numerical cosmology
- 3. From dark matter halos to galaxies
- 4. Alternatives to a cosmological constant
- 5. Cosmic Microwave Background
- 6. Gravitational Lensing
- 7. Gravitational Lensing of the CMB
- 8. CMB polarisation and GW from inflation
- 9. Galaxy clusters as cosmological probes
- 10. The Sunyaev-Zel'dovich effect
- 11. Strong gravitational lensing
- 12. Non-Einsteinian gravity
- 13. Gravitational waves and cosmology
- 14. Galaxy clustering and baryon acoustic oscillations
- 15. The Lyman-alpha Forest & the Intergalactic Medium
- 16. First Light & Cosmic Reionization
- 17. Cosmological tests of gravity
- 18. Growth of linear cosmological fluctuations
- 19. Baryogenesis
- 20. Reheating in inflation

Elements of a Seminar Talk

- Spend your time to convey the most
  - new
  - important
  - likely correct

  insights to be gained from the paper(s)

  [Don’t need to discuss everything in the paper(s)!]
- Briefly set the stage:
  - What is the question, puzzle, observation to be understood
  - You may draw a (few) plot(s) from other articles as well

Elements of a Seminar Talk

- What are the "punchline(s)" or key insight(s)?
- Is that based on a new
  - calculation
  - idea
  - data
  - technology
- What are broader implications of the results?
  - based on the author's view, filtered by your judgement
- Are these insights/conclusions (in your judgement)
  - clearly presented?
  - persuasive?
  - is speculation clearly separated from sound fact?
  - [much of the refereed literature is good, innovative, but not all. Don't believe everything you read!!]

Preparation

- Plan to spend about 2 weeks preparing your presentation with your partner
  - could be longer depending on fluency in English
  - read a few other papers/references to enhance understanding
- The references in the topic list are:
  - popular articles, commentary
  - project/telescope websites
  - online tutorials
  - review articles
  - journal articles

We are available to answer questions and go over slides beforehand.

9. The Sunyaev-Zel'dovich Effect

South Pole Telescope: http://pole.uchicago.edu

Atacama Cosmology Telescope: http://www.physics.princeton.edu/act

Planck Satellite: http://sci.esa.int/planck/

Review Article: *Cosmology with the Sunyaev-Zel'dovich Effect*
Carlstrom, J. E., Holder, G. P., & Reese, E. D. 2002, ARAA, 40, 643
http://adsabs.harvard.edu/abs/2002ARA%26A..40..643C

Review Article: *Tracing cosmic evolution with clusters of galaxies*
Voit, G. M. 2005, Reviews of Modern Physics, 77, 207
http://rmp.aps.org/abstract/RMP/v77/i1/p207_1

Article: *The Atacama Cosmology Telescope: Cosmology from Galaxy Clusters Detected via the Sunyaev-Zel'dovich Effect*
Sehgal, N., Trac, H., Acquaviva, V., et al. 2011, ApJ, 732, 44
http://adsabs.harvard.edu/abs/2011ApJ...732...44S

Article: *A Sunyaev-Zel'dovich-selected Sample of the Most Massive Galaxy Clusters in the 2500 deg2 South Pole Telescope Survey*
Williamson, R., Benson, B. A., High, F. W., et al. 2011, ApJ, 738, 139
http://adsabs.harvard.edu/abs/2011ApJ...738..139W

Article: *Discovery and Cosmological Implications of SPT-CL J2106-5844, the Most Massive Known Cluster at z>1*
Foley, R. J., Andersson, K., Bazin, G., et al. 2011, ApJ, 731, 86
http://adsabs.harvard.edu/abs/2011ApJ...731...86F

Article: *Planck 2013 results. XX. Cosmology from Sunyaev-Zeldovich cluster counts*
Planck Collaboration 2013, arXiv:1303.5080
http://adsabs.harvard.edu/abs/2013arXiv1303.5080P

Choose Your Topics

- We will soon set up a doodle poll with the topics. Please indicate 4 possible topics in this list by the subsequent Friday. **And leave your email in the doodle comments!**
- Topics will be assigned on a first-come first-serve basis

Your Grade

- Seminar is 4LP
- **Regular attendance is mandatory**! If more than 1 meeting is missed, you will fail unless special arrangements are made.

Schedule

- May 2, today
- May: free
- Then every Friday (calendar TBC)
- Meet 14:15–16:00 here

Scientifically Speaking

Generalities

- Think about your audience first
  - what do they already know?
  - what will get them excited about your topic?
  - what is minimal & sufficient information to make your point?
- The first and last slides are most important
  - spell out your first 5 and last 5 sentences verbatim
- Two days later your audience will remember either 0 or 1 of your points. So tell a story

Generalities

- Give a clear exposition of the scientific issue
  - what is the question being addressed?
  - why is it interesting?
  - state the obvious, but only briefly
- Practice your talk all the way through before you present it.
- Put your name on every slide!

Practicalities

- Budget 2-3 minutes per slide
  - never, ever run over your time limit
  - make intermediate time marks for yourself
  - recognize which slides you can skip if you are behind
  - never say “I think I’ll stop here” or “I’m running out of time”

Practicalities

- Budget 2-3 minutes per slide
  - never, ever run over your time limit
  - make intermediate time marks for yourself
  - recognize which slides you can skip if you are behind
  - never say “I think I’ll stop here” or “I’m running out of time”
- Use figures extensively, but annotate them
  - legible axes! (modify or annotate original plots)
  - if there are several lines, add labels with colors
  - don’t show dense tables

Practicalities

- Budget 2-3 minutes per slide
  - never, ever run over your time limit
  - make intermediate time marks for yourself
  - recognize which slides you can skip if you are behind
  - never say “I think I’ll stop here” or “I’m running out of time”
- Use figures extensively, but annotate them
  - legible axes! (modify or annotate original plots)
  - if there are several lines, add labels with colors
  - don’t show dense tables
- Explain everything on slide, or don’t put it on the slide
- Streamline: if a slide has no bearing on your conclusions, omit it

Equations??

- Complicated equations usually add very little to a presentation.
  - if you must show equations, talk through meaning
  - remember this will slow you down
  - substitute heuristics whenever possible

Fonts??

- Complicated equations usually add very little to a presentation.
  - if you must show equations, talk through meaning
  - remember this will slow you down
  - substitute heuristics whenever possible
- Use readable font size. Recommended font > 24 pt. This is 38pt.

Colors??

- Complicated equations usually add very little to a presentation.
  - if you must show equations, talk through meaning
  - remember this will slow you down
  - substitute heuristics whenever possible
- Use readable font size. Recommended font > 24 pt. This is 38pt.
- Colorized text is useful for highlighting an issue, but do not over-colorize!

Logic??

- Complicated equations usually add very little to a presentation.
  - if you must show equations, talk through meaning
  - remember this will slow you down
  - substitute heuristics whenever possible
- Use readable font size. Recommended font > 24 pt. This is 38pt.
- Colorized text is useful for highlighting an issue, but do not over-colorize!
- If you make complex arguments, or switch topics, provide a summary of preceding logical progression

Delivery

- Studies of interpersonal communication show that:
  - 55% comes from facial expressions and body language
  - 38% comes from vocal quality or tone of voice
  - 7% comes from content, actual meaning of the words
- Speak in a conversational tone
- Smile!
- Never simply read what is on the screen!
- Face the audience, don't talk to the screen
- Animations can be useful, but if overdone they are very distracting

Most Importantly

HAVE FUN!!!