Basic Background Knowledge (8th Oct 2019)

Try to provide short answers for as many of these as possible. (We are looking for basic outlines, not in-depth scientific reviews!)

1. What is \(2GM_\odot/c^2\) and what is its approximate numerical value?

2. What are the main components of a spiral galaxy?

3. What methods are used to estimate the masses of galaxies? Explain the scaling relations.

4. What are the differences between spiral and elliptical galaxies? What different types of spiral galaxies do you know? Which type of galaxies contains young stars, and where in those galaxies can they be found? Why are some galaxies red, others blue?

5. What is the surface-brightness profile of an elliptical galaxy? Can this profile also be found in spiral galaxies?

6. What evidence is there for a supermassive black hole in the centre of our galaxy? What about SMBHs in other galaxies?

7. What is the ‘distance ladder’? What are the methods for measuring extragalactic distances? How do we determine the Hubble constant?

8. What are basic properties (e.g. size and mass scales) of (a) galaxy groups and (b) galaxy clusters?


10. Describe methods to determine the masses of galaxy clusters.

11. Why are we confident that there is a dark matter component in addition to baryonic matter? Which observations support this assumption?

12. What physical candidates do you know of that could fulfill the role of dark matter?

13. What are the predictions of the standard cosmological model? What are some of the problems of the standard model?

14. What is the CMB and how was it generated?

15. What are primary and secondary anisotropies of the CMB? Explain the most important primary anisotropies.

16. What is the amplitude of the anisotropies and what do we learn from them?

17. What is the fundamental concept on which the theory of gravitational lensing is based?
18. What is an Einstein Ring and when does it occur? How is magnification defined in the context of a lens mapping? Which quantities (intensity, flux, solid angle, etc) are conserved in a lens mapping?

19. What is the ‘cosmological principle’? What observations support its assumptions?

20. How are ‘comoving coordinates’ defined? How does a system evolve in comoving coordinates, if it is (a) growing with, or (b) decoupled from, the expansion of the universe?

21. Describe the following epochs of the Universe: radiation domination, neutrino decoupling, pair annihilation, primordial nucleosynthesis, recombination.

22. Write down the first Friedmann equation in terms of cosmological density parameters (Ω). Describe the meaning, properties and behaviour of the individual density parameters. What are their values today? Order the individual components according to which was the dominant energy-density component first.

23. Which observational methods are used to determine cosmological density parameters?

24. Which quantities can be used to express distances in cosmology? How are they related?

25. How does the Universe evolve from an almost homogeneous early state (e.g. the CMB is nearly isotropic), to the filamentary structure that is observed today? How can we observe the growth of structure? What is the difference between Hot Dark Matter and Cold Dark Matter? Which model is preferred today? Why?

26. Explain how distances in cosmology are measured? What is angular diameter distance, what is luminosity distance? Explain why they are related according to $D_L(z) = (1 + z)^2 D_A(z)$.

You can find the exercise sheets, class details, contact information, literature references and other important links on our web page:

https://www.astro.uni-bonn.de/~Cosmo