April 27th , 2004 | **Astronomy 100** | Dr. Warner

Review for the final exam

DISCLAIMER: THESE NOTES SHOULD HELP FOR THE PREPARATION OF THE FINAL EXAM. THEY INDICATE HOW TO DISTINGUISH THE ESSENTIAL FROM THE LESS ESSENTIAL MATERIAL. HOWEVER, THEY ARE NOT MEANT TO BE A COMPLETE LIST OF THE ESSENTIAL MATERIAL. **CAVEAT EMPTOR**

The final exam is intended to be cumulative, but it will be strongly weighted towards the material that has not yet appeared on earlier exams. I intend that somewhere about 50% of the questions to focus on material that we have covered since midterm 3. The remainder will be made up of, and hopefully spread evenly over, material appropriate to midterms 1, 2 and 3. Since the older material is about 80% of the course, I will not be able to ask enough questions to cover everything, and so it may just happen that your favorite subject may not even be covered on the final exam - be warned. I will, however, attempt to cover as much as possible.

There will be **one qualitative difference** in **some** of the questions on the final: there will be questions that strictly do not belong to any single one of the midterm sections, but will involve a mixture of the parts of the course. As a very elementary example, consider the question: *Which of the following has the largest size: a) a planet b) a galaxy c) the Sun d) a globular cluster*. This question does not belong to one of the topics tested in the midterms, because it requires knowledge of the whole course. The final exam will contain a few such questions.

For reviews of the course material up until midterm 3, SEE THE REVIEW SHEETS FOR MIDTERMS 1,2 AND 3 and the handouts on Planets and Stars. As with the midterms, you will also find it useful to review the posted homework solutions, the old final and, of course, your lecture notes.

The following is intended as a review of the essential material since midterm 3.

First, we did not cover everything listed on the syllabus. As usual, the best guide to what we covered are your lecture notes and the homework. Below, I will try to summarize the sections that we actually covered.

Deaths of Stars and Stellar remnants:

White dwarfs and neutron stars was covered prior to midterm 3. The final exam will therefore focus primarily upon the last stellar remnant: the black hole. We devoted about a lecture to this topic and covered some of the key ideas of special and general relativity: The constancy of the speed of light, and its counterintuitive consequences for the addition of speeds. Michell's dark star. Einstein's theories relativity. Time dilation. The effect of mass/energy on the geometry of space and time. The "flatlander analogy/model." The effect of gravity upon light. Experimental tests of relativity. Event horizons, and the Schwarzschild radius (and its size for a one solar mass black hole). The (curvature) singularity and tidal force.

My presentation here overlapped significantly with the material in Chapter 24, but there were also very significant differences in approach. The exam will be based mainly upon my lectures.

Galaxies: The Milky Way (= the Galaxy = Our Galaxy) and Beyond, Ch. 25,26

We covered most of chapter 25, except for section 25.6. We also covered most of chapter 26, but we only touched superficially upon sections 26.7 and 26.9.

Please note i) we only discussed the Shapley-Curtis debate very briefly in class, and ii) we did not cover

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sections 25.5 and 26.3 in class, **however** there were homework problems that essentially asked you to review this material, and so I expect you to at least know the material covered by the homework question.

Other subjects covered include:

The basic size, scale and specifications of our Galaxy (length, bulge diameter, thickness, mass, number of stars, luminosity.....) and our position in it. The problems of interstellar extinction, and how our location in our Galaxy was finally determined. How the size of our Galaxy was determined. The role played by globular clusters. What globular clusters are. How we measure distances to things inside and outside our galaxy, and the difficulties involved. The use of variable stars in this context. The limitations of parallax, and the Hertzsprung-Russell diagram in measuring distances. The importance of radio astronomy and 21cm lines in mapping out the location of hydrogen, and determining its motion. The spiral structure of the Milky way, and how it is moving. Spiral arms, and what is going on in them. The winding dilemma. The mass of the galaxy, rotation curves of our, and other, galaxies and the missing mass, or dark matter problem. The possible forms that the missing/dark matter might take. We also talked once again about the "Harvard Computers," and Henrietta Leavitt in particular.

Other galaxies: early ideas as to what spiral nebulae might be. The Shapley-Curtis debate. The different kinds of galaxies: ellipticals, spirals and irregulars, and their basic characteristics. The characteristics of the "local group", and other clusters. The typical distances to, and the scales of these things (roughly). Yet more methods and difficulties of determining distance (supernovae, Tully-Fisher, Hubble flow). Clusters, superclusters and voids - how the matter is distributed on very large scales. Motion of galaxies within clusters, and further evidence for missing mass. Gravitational bending of light/lensing and mass measurement

<u>Very Important:</u> The Hubble flow, and the cosmological red-shifts of galaxies.

<u>Active Galaxies, Ch. 27</u>

Sadly the primary content of this chapter was omitted owing to lack of time. However, I did ask you to read sections 27.1 and 27.2, and glance at the figures on pp. 632/3. So one or two very general questions might be fair game. <u>Important:</u> We did cover the idea of "look-back time".

<u>Cosmology and the Universe at very large scales Ch. 28 (29)</u>

We covered most of chapter 28. We also touched on a very small part of 29.3 and 29.4.

Interpreting the Hubble flow in terms of an expanding universe. Einstein's theory of general relativity and the "shape of the universe". The inflating balloon/stretching rubber sheet ("Flatlander") model, and its implications. The fact that we are not in the center of this expansion: any observer, anywhere in the universe will see the same Hubble flow. The Big-Bang. The Hubble constant, and its relation to the age of the universe. Uncertainty in the value of the Hubble constant. The Hubble flow as a method of determining distance. Looking outward = looking backwards in time. The "stretching of scales" as the universe expands. The primordial fireball and the cosmic microwave background. Prediction of the relative Hydrogen/Helium/Lithium/... abundances. The ultimate fate of the universe and the critical mass density. Average mass density and the spatial geometry of the universe. Dark energy, and the acceleration of the universe.

I hope this review sheet, and all the previous ones have been helpful. Indeed, I hope that you have found the entire course helpful, interesting and thought-provoking. Good luck, and all the best.

Nick Warner