ASTR 323/423 Final Exam Study Questions
Final Exam: Dec 18th, 12pm-3pm, Sears 552
Bring a (non-phone) scientific calculator!

The final exam will consist of ~ four essay questions taken from the list below, as well as two mathematical/calculation problems.

For the essay questions, your written responses ought to be about 1.5-2 blue book pages long, excluding any sketches. Significantly shorter than that and you probably aren't giving a thorough enough explanation. Much longer than that isn't necessary, unless you are particularly wordy in your writing.....

Regarding sketches: All sketches should include labeled axes and descriptions ('blue', 'red', 'bright', 'faint', etc), but do not worry about numerical values unless specifically asked. You should also mark where the Sun (for plots of stars) or the Milky Way (for plots of galaxies) lies on the plot.

For the calculation problems: You will be expected to know the following equations (what they mean, how to use them, and the units involved):

$$m_1 - m_2 = -2.5\log(f_1/f_2) \qquad m - M = 5\log d - 5$$
$$M - M_\odot = -2.5\log(L/L_\odot) \qquad d = 1/p$$

A list of all other necessary constants and (astronomy) equations you might need will be given to you with the exam.

Potential Exam Essay Questions:

1. Sketch the color magnitude diagrams (CMDs) you'd expect to see for stars in the following galaxies:

- A massive E0 galaxy
- A low mass E5 galaxy
- A barred SBb galaxy
- A star-forming dIrr galaxy
- A dwarf spheroidal galaxy

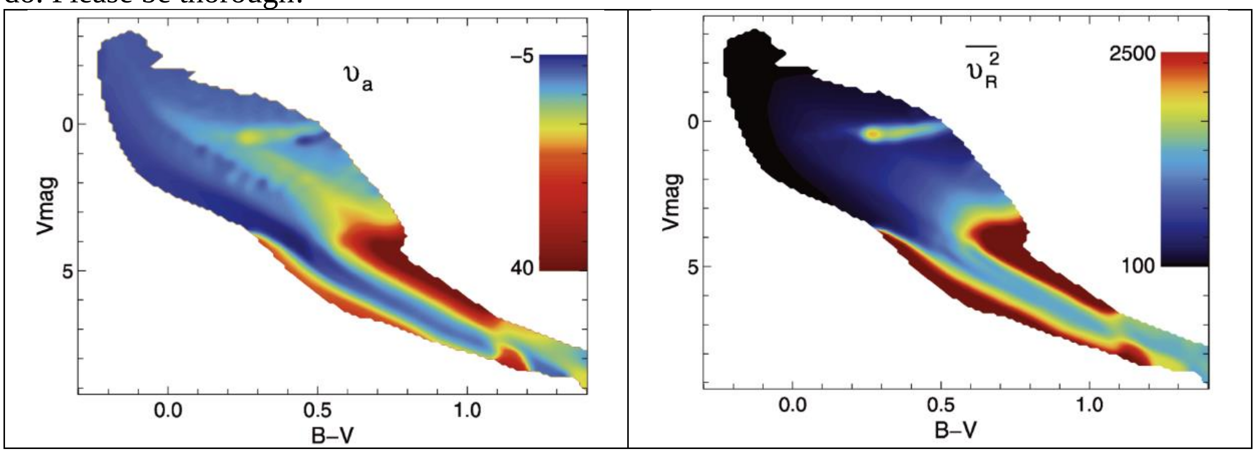
Describe the differences and similarities between the different CMDs, and explain physically what is different about the galaxies that gives rise to those CMD differences.

2. The gas in the interstellar medium of galaxies can be found in four different phases. Describe these phases, how they emit radiation, and how we detect each of them. Which phases are predominantly found in spirals, and which in ellipticals?

3. Describe the cycling of baryons in galaxies via star formation and feedback, and how it impacts the chemical evolution of a galaxy. Describe why the average metallicity of a galaxy can change over time, and give a physical explanation for the mass-metallicity relationship we see in galaxies.

4. Describe and sketch the Schechter function, and explain what the parameters M* and alpha refer to. How does the Schechter function change with environment and galaxy color? How do different types of galaxies populate the Schechter function, and how does this change with environment?

5. Explain in detail what the figures below are showing, and explain why they look the way they do. Please be thorough!



6. Define [α/Fe] and [Fe/H]. Describe how we can use plots of [α/Fe] vs [Fe/H] to learn about the star formation history of different stellar populations. Make a sketch of the plot, showing how it would differ for populations with different star formation history. On this plot, where the following populations lie?: The Milky Way's thin disk stars; the Milky Way's thick disk stars; stars from a massive elliptical galaxy. Explain your reasoning.

7. Describe how the Oort limit constrains the local mass density in the Milky Way's disk. The vertical velocity dispersion is different for different groups of stars; describe how and why it changes as you look at different stellar populations in the disk. If you measure the Oort limit with different stellar populations, should you get a different answer? Explain why or why not.

8. As a function of luminosity and surface brightness, disk galaxies show trends in their colors, metallicities, and gas content. Individual disk galaxies *also* show similar trends in these properties with radius. Describe these trends, and explain how density and star formation may be driving many of these trends.

9. Describe what we mean by Sersic-n, and what typical values are for disk galaxies and elliptical galaxies. Sketch the following plots for a large sample of many different types of galaxies:

- color vs absolute magnitude (for galaxies as a whole, not for their individual stars)
- color vs Sersic-n
- absolute magnitude vs Sersic-n

On these plots, indicate where different galaxy types can be found. In the color-magnitude plot, indicate the red sequence and the blue cloud, and explain why the red sequence has the shape that it does. Finally imagine a spiral galaxy falling into a big galaxy cluster. As it falls in, it experiences a burst of star formation as its interstellar medium (ISM) is shocked by the hot gas of the cluster, but then its ISM is swept away by the cluster gas and it stops forming stars altogether. Sketch how it might change position on those three plots as it evolves with time during and after this process. Describe your reasoning.

10. There are systematic differences between the most luminous elliptical galaxies and ellipticals of intermediate luminosity. Describe these differences and how they might relate to how these different types of galaxies may have formed.

11. Describe what we mean by dynamical friction when we talk about objects orbiting a galaxy. Physically, what is going on? What physical properties of the system does it depend on, and why does it depend on them the way it does? Which of the following systems would be affected most strongly by dynamical friction? Which would be affected the least? Explain your reasoning

- A globular cluster on a circular orbit at a distance of 10 kpc.
- A dwarf galaxy on a circular orbit at a distance of 10 kpc.
- A dwarf galaxy on an eccentric orbit with pericenter distance of 10 kpc.

12. Many galaxies show evidence for a supermassive black hole (SMBH) in their centers. How does the mass of the SMBH depend on the properties of the galaxy as a whole? Explain why we believe that the growth of galaxies and their central black holes may be linked, and describe two ways that SMBHs might affect their host galaxy.

13. Describe how the merger of two spiral galaxies can lead to the formation of an elliptical galaxy. Be sure to talk about things like morphology, kinematics, gas content, stellar populations, and nuclear/black hole properties.

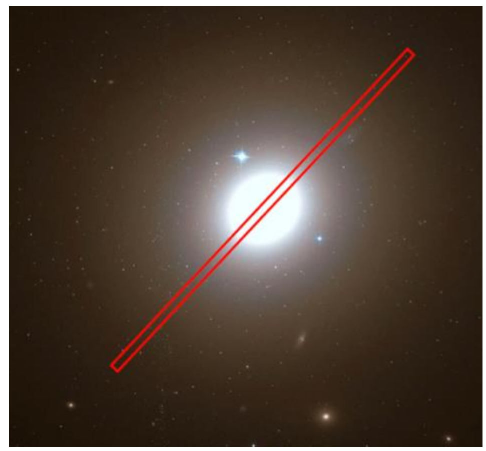
14. Describe the satellite galaxy population around the Milky Way (their morphological types, masses, sizes, star forming history, etc). Describe two ways in which the Milky Way might have altered the properties of its satellite galaxies, and give a piece of evidence for each.

15. Describe and sketch the inner structure of an active galactic nucleus (AGN). Describe "Type1" and "Type2" AGN, and how this model explains the differences. Explain three ways to search for AGN, and why they work (i.e., what aspect of the AGN are they detecting, and why are they efficient at differentiating AGN from normal galaxies).

16. Both elliptical galaxies and spiral galaxies show “scaling relations” between their various properties. The most important of these are the Tully-Fisher Relation and the Fundamental Plane. Describe in words what these relationships involve, and explain in detail how you would use each one to get distances to galaxies. In other words, what properties of the galaxy could you measure observationally, and how would you use those measurements with the TF or FP relationship to derive a distance?

17. Explain how the surface density of a disk galaxy is important both in terms of the star forming properties of the disk and its ability to form bars or spiral structure. What properties of a spiral galaxy would make it less susceptible to forming a bar in the first place? Given your answer to that question, give examples of a few types of disk galaxies that would be least likely to have bars.

18. Describe the kinematic properties of ellipticals, and how their kinematics relate to their shape. In this context, describe what we mean by “pressure supported” or “rotationally supported” flattening. Explain also what is meant by “radial anisotropy”. Let’s say you measured the kinematic properties of an elliptical galaxy along the major axis (i.e. along the red slice in the figure to the right). Make sketches of what the velocity and velocity dispersion profile would look like if the galaxy had no radial anisotropy to its kinematics. Sketch also how these profiles would change if the galaxy had large radial anisotropy. Explain the differences.



19. Describe what the morphology-density relationship is, and how galaxy populations in massive galaxy clusters are different from those in the field environment. Explain how these differences arise as galaxy clusters form and grow with time — physically, how are different processes operating inside a galaxy cluster to change the galaxy populations.

20. Think about a gas-rich star forming satellite galaxy being accreted into the Milky Way galaxy’s halo. Describe what would happen to it as it evolved over long time scales. Think about changes to its morphology, mass, gas content, star-forming properties, and orbit, and describe physically why these things would change over time.

21. Hierarchical galaxy formation models say that low mass galaxies should be the first galaxies to form, and that more massive galaxies form later. But when we look at stellar populations in galaxies, the most massive ellipticals have the oldest stellar ages, while dwarf galaxies often have some of the youngest stellar populations. Describe how we can reconcile these seemingly inconsistent statements; that is, explain how both statements can be true.

22. Here is a plot of galaxy color versus the log of the galaxy's stellar mass (in solar masses). On the plot I have marked 4 galaxies. What kind of galaxy do you think galaxies A, B, and C are *most likely* to be? What is the *most likely* explanation for the difference in color between galaxies A and B? Describe physically why this difference leads to the color difference. What is the *most likely* explanation for the difference in color between galaxies B and C? Again, describe physically what leads to the different colors. What do you think is going on with galaxy D? Give a plausible physical explanation for why a galaxy might appear in that part of the plot.