Astronomy 253:
Galactic Astrophysics

http://brahms.phy.vanderbilt.edu/a253

Syllabus Revision 6 (2004-03-24)

Spring, 2004
MWF, 1:10 PM, Stevenson Center 6105

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Office Hours: Tu 10:00-11:00; W 2:00-4:00; Th 10:00-11:00

Textbook

Sparke & Gallagher, *Galaxies in the Universe*, 2000, Cambridge University Press. (S&G)

Other Recommended Books

These books are not required for the course, but you may find them helpful if you are looking for more information.

- Binney & Merrifield, *Galactic Astronomy*, 1998, Princeton University Press. The standard graduate-level text on the topic.
- Binney & Tremaine, *Galactic Dynamics*, 1987, Princeton University Press. The companion volume to the previous text, this one goes into amazingly gory detail about the theory of stellar dynamics. Also a graduate-level text.

Topics in the Course

The course will be broadly divided into four primary topics.

Topic I Background Astronomy. This is a catch-all topic for a crash course in introductory astronomy, specifically to the level relevant to this course. Those of you who have had Astro 102 will have a leg up here, but we will go into greater depth with some things, and will be more technical about some things. The three main subtopics will be astronomical measurements (magnitudes, colors, spectra, velocities, distance moduli, etc.), stars (the H-R diagram, stellar classification, stellar evolution), and galaxy classification (the Hubble sequence, morphology). *S&G Chapter 1; Chapter 2–2.1.1.*

Topic II Stellar Populations & Chemical Evolution. We'll go over the different "populations" of stars and their distribution in the galaxy (and in galaxies), star clusters, as well as the gas in the galaxy from which stars form, and how heavy elements build up in the gas and in the stars, and the end of the Cosmic Dark Ages. *S&G Chapter 2.1.2–2.2.4, 2.3.2–2.3.3; Chapter 4–4.4 (skipping 4.1.4); Chapter 5–5.2; Chapter 6–6.1, 6.3.*

Topic III Galactic Dynamics. We'll discuss the rotation of the Milky Way, measuring distances from redshifts, dark matter, stellar dynamics in general, relaxation timescales, and gravitational potentials. *S&G Chapter 2.3; Chapter 3; Chapter 4.1.4, 4.5; Chapter 5.3–5.6; Chapter 6.2, 6.4-6.5.*

Topic IV Cosmology and Large-Scale Structure. The big bang, the expansion of the Universe, formation and evolution of galaxies, growth of clusters, groups and clusters, filaments, voids, 42. *S&G Chapter 7.*

Format of the Course

Lectures and Class Work The course will meet three times a week. About once a week, instead of me talking at you and trying to elicit questions, you will break into teams of 2–3 to work on quesitons and problems together. Your solutions to these problems will contribute to your grade.

Reading and Reading Questions Reading assignments should be completed *before* class on the day they are assigned. In order for you to get the most out of class time, you will need to have thoughtfully read them. To this end, there will be online "reading questions": short, largely conceptual (though occasionally calculation-based) questions that both test your basic comprehension of the reading, as well as challenge you with deeper questions to get your brain working. Your grade on these "reading questions" will be based on your having made a serious and thoughtful effort with them, not on how "right" your answers are. If you make an honest effort at them, they will form the basis for our discussions in class and will make class time more useful.

Problem Sets There will be a small number of problem sets for you to do as homework. In each problem set, there will be one or more "solo problems", which you are to work out yourself without discussing it with other members of the class. You may discuss the other problems with other members of the class, though of course any final answers and solutions must be your own. You may, of course, come to me with questions about any problem, solo or otherwise.

Exams There will be two midterm exams and one final. These will be administered in-class. They will be closed-book and closed-notes, but you will have a sheet of equations, formulae, and data with each test, so you need not memorize any of that sort of thing.

Project Finally, you will complete a project, the nature of which is very flexible. This is discussed in greater detail on the next page.

Grade

Your grade in the course will be based on the following:

Lecture Participation ..	5%
Group Problems	10%
Reading Questions	10%
Individual Problem Sets	10%
Exam 1	10%
Exam 2	10%
Final Exam	25%
Project	20%

"Lecture participation," by default, will equal your average in the class. It cannot hurt you, it can only help you if you stand out.

"Group Problems" are the problems given in class. For each problem, everybody in your group will receive the same grade, based on how correct your solution is (or how far you got with a partial solution).

"Reading Questions" are graded **only on effort**, not on how right your answers are. You will receive 0-2 points for each question (0: not done or no useful effort; 1: weak or perfunctory effort; 2: you took the question seriously and gave a thoughtful answer).

The Project

The project you will complete for this course will be some work you do on your own that addresses something relevant to Galactic Astrophysics. The amount and nature of the work for the project will vary greatly based on the nature of the project. (If you choose your project well, some of the "work" you do it won't "seem like" work!) The goal of the project is to learn something in fair depth relevant to the course that *you* find particularly interesting. The project may fit one of the following descriptions:

Observational At Dyer Observatory, there is a 24″ telescope, equipped with a CCD camera and photometric filters. Although this is no longer really a research-grade astronomical instrument, you can still do some good work with it. You might use this, for example, to compare the morphologies and colors of a number of nearby galaxies, to measure the distance to M32 using the surface-brightness fluctuation method, to measure the lightcurves of bright variable quasars, or to perform another project. If you have an idea or the glimmerings of an idea, feel free to discuss it with Dr. Knop. You would turn in your data and analysis, using whatever pages are necessary to fully explain them. Although images, data, and tables could well occupy several pages, I would expect something like 3-4 pages (900-1200 words) of text in the write-up.

Computational If you're good with computer programming, you might perform a numerical computation relevant to galactic astrophysics. This could include a N-body simulation of stellar dynamics in colliding galaxies, a simulation of the Stochastic Self-Propagating Star Formation model for flocculent spiral structure, or other things. You might even combine an Observational project with a Computational project, where you (for example) to obtain images of a number of elliptical galaxies and attempt to fit them using a standard $R^{1/4}$ elliptical galaxy profile. The write-up would be similar to what is expected for an observational project.

Data Mining There is a large quantity of astronomical research data available on the web: various NASA missions, the Sloane Digital Sky Survey, digitized versions of the Palomar Sky Survey, etc. If you come up with an interesting topic that involves finding and making measurements of archived data, that could form a very good project for the course. The write-up would be similar to what is expected for an observational project.

Technical Paper If library research and detailed understanding of a given theory or observational result is more to your liking, you could write a paper which summarizes and makes accessible to other members of the class a given technical topic. For example, you might investigate and explain the Lin-Shu theory of spiral structure, the connection between particle physics and astronomy in the early Universe and astronomical constraints on the number of neutrino families, or something else that strikes your fancy. I would expect the equivalent of a 5-page (1500-word) paper, plus any necessary supporting figures. You could do this in the form of a website rather than a paper; if you're really ambitious and have sufficient geek credentials, you might even include animations or Java applets to help make your point.

Popular Paper In this form of the project, you would write the equivalent of an article for a popular audience that makes clear a topic from galactic astronomy such as might be found in a general-audience science magazine. For example, write a paper on the structure of the Universe (clusters, filaments, voids), and how it got that way; or, explain quasars to a popular audience, including what they tell us about the history of our Universe. Again, anything you can do a good job on which is relevant to the course may work. The topic should be meaty enough to support a well-written and well-explained paper of roughly 8 pages (2400 words), or a website with the equivalent amount of well-organized and proofread text.

Naturally, for all projects, you should be careful to cite any references, and to follow the usual rules of good style and writing.

You will have the first few weeks of the course to think about and discuss ideas for a project with me (and each other!). Ideally, I would like a mix of types of projects from students in the class. Some projects (especially observational ones, which depend on the weather and may require several observations) may require you to get started fairly early. By the fourth week of the course, you should have chosen your project (subject to my approval). The project will be due near the end of the term.

You will give an in-class 15–20-minute presentation on your project. You are encouraged to actively engage others as they present their project, asking questions and discussing their results. The nature of the presentation will vary depending on the nature of the project; an observational project might prompt a "research talk", while a popular paper might prompt the equivalent of a short popular lecture.

Course Schedule — Revision 6 (2004/03/24)

Date		Topic	Reading and Assgignments
W	01/14	Cool Pictures; Morphology	
F	01/16	Spectra, F_λ	S&G Ch. 1–1.1, p. 1–23
M	01/19	Filters, Magnitudes, Star Colors	S&G Ch. 1.2–1.3, p. 24–40
W	01/21	The H-R diagram; Stellar Classification	S&G Ch. 2–2.1, p. 51–59
F	01/23	Group Problems	—
M	01/26	Stellar Evolution	re-read S&G 1.1.3, p. 9–16
W	01/28	Distances to Stars & Clusters	S&G 2–2.1.1, p. 51–55; 2.2–2.2.2. p. 59–67
F	01/30	Group Problems	**Problem Set 1 Due**
M	02/02	Milky Way: Stars & Coordinate Systems	re-read S&G 1.2, p. 24–31; 2.1.2 p. 55-59
W	02/04	Star Clusters & Stellar Populations	S&G 2.2.3–2.2.4, p. 67–77
F	02/06	Group Problems	**Choose your Project by today!**
M	02/09	Spiral Galaxies	S&G 5, p. 172–173; 5.1.2, p. 178-187
W	02/11	Gas in Spirals	S&G 2.3.2–2.3.3, p. 84-89; S&G 5.2 p. 187-194
F	02/13	Group Problems	—
M	02/16	Elliptical Galaxies	S&G 6–6.1, p. 231–245
W	02/18	Gas in Ellipticals	S&G 6.3, p. 257–264
F	02/20	Group Problems	**Problem Set 2 Due**
M	02/23	Dwarf Galaxies; The local group	S&G 4–4.1.3, p. 132–146
W	02/25	Chemical Evolution	S&G 4.3.2, p. 157–164
F	02/27	Group Problems	—
M	03/01	**EXAM 1**	—
W	03/03	Milky Way Rotation	S&G 2.3–2.3.1
F	03/05	Rotation of Spirals; Dark Matter	S&G 5.3, p. 194–205
M	03/15	Gravity, Potentials, Virial Theorem	S&G 3–3.1, p. 95-107
W	03/17	Gravity, Potentials, Virial Theorem	(S&G 3–3.1, p. 95-107)
F	03/19	(Basketball Game)	—
M	03/22	Group Problems	—
W	03/24	Gravity, Potentials, Virial Theorem	(S&G 3–3.1, p. 95-107)
F	03/26	Star-star interactions	S&G 3.2, p. 102–116
M	03/29	Galactic Cannibalism	S&G 4.1.4, p. 146–150; 4.5, p. 169-171
W	03/31	Spiral Structure	S&G 5.4–5.5, p. 205-221
F	04/02	Group Problems	**Problem Set 3 Due**
M	04/05	Large-Scale Structure	S&G p. 281–292
W	04/07	The Expanding Universe	S&G 1.4, p. 40-50; 7.2, p. 292–298
F	04/09	Group Problems	**Projects Due**
M	04/12	**Exam 2**	—
W	04/14	Presentations: Colgan; Welsh	TBA
F	04/16	Presentations: Mashburn; Busbee	**Observational Projects Due**
M	04/19	Presentations: Rexroth; Pablo	TBA
W	04/21	Presentations: Stricker; Harmon & Grey	TBA
F	04/23	Presentations: Collazzi; Givens & Mahmud	TBA
M	04/26	Life, The Universe, and Everything	Don't Panic!