ASTRON 449: Stellar Dynamics (Fall 2014)

This course provides a broad introduction to galaxies and their dynamics. It lays the foundations for research in many areas of Galactic and extragalactic astrophysics, and should be regarded as essential for graduate students pursuing astrophysical research.

It will answer questions including: How do we know that there is a supermassive black hole at the center of most galaxies, and a halo of dark matter around all galaxies? What is the origin of spiral structure in disk galaxies, and how do elliptical galaxies form? What happens when two galaxies collide? How do the dynamics of galaxies differ from the dynamics of dense star clusters?

Instructor: Prof. Claude-André Faucher-Giguère
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Office: Tech F243
Office hour: TBD
Course website: http://galaxies.northwestern.edu/teaching (follow links).

For questions about course material and homework assignments, please come to the office hour.

Time and location: Tuesday and Thursday, 9:30-10:50, in Tech LG62.

Textbook (required): Galactic Dynamics (Second Edition) by James Binney & Scott Tremaine (BT2). Princeton University Press (ISBN: 9781400828722). Be sure to get the second edition as it contains substantial new material.

Other useful references: Galactic Astronomy by James Binney & Michael Merrifield. Princeton University Press (ISBN: 9780691025650). Complementary, more observationally-oriented, textbook.

Similar courses have been taught elsewhere and their websites may contain useful supplementary materials:

Scott Tremaine: https://www.sns.ias.edu/tremaine/lectures/ast513
Sylvain Veilleux: http://www.astro.umd.edu/∼veilleux/ASTR620/fall11
Mark Whittle: https://www.astro.virginia.edu/class/whittle/astr553
Paul Schechter: http://ocw.mit.edu/courses/physics/8-902-astrophysics-ii-fall-2004/index.htm

Most of the material for this course will be drawn from BT2, but we will not systematically cover all the material in the book (that would not be possible). Rather, we will focus on topics that are of particular interest and usefulness for modern research in Galactic and extragalactic astrophysics. This includes numerical methods to compute the dynamics of stars and dark matter.

Course pre-requisites: The course is targeted primarily at graduate students with an interest in astrophysics. Motivated undergraduates who have completed the main courses of the physics major curriculum may also take the course, but should consult with the instructor to ensure that they are sufficiently well prepared.

The most important requirements are a background in classical mechanics and statistical mechanics at level of PHYSICS 330-1,2 and PHYSICS 332-0. I will assume a mastery of multi-variable calculus. Some topics will also require familiarity with elementary fluid mechanics, though the basic equations will be reviewed.

This course does not have a specific astronomy requirement, but students should be familiar with astronomical terminology and the astronomical context (e.g., what is a galaxy? what is a black hole? what is the interstellar medium? what is a redshift?) at the level of ASTRON 220. If you have never taken a broad astrophysics course before, you should consult with the instructor. Reading beyond the material covered in class will be assigned to provide further context.

Since we will cover numerical methods, I will also assume some familiarity with computer programming and problems that require coding may be assigned. I recommend the Python programming language but students can use a language of their choosing.

Course evaluation: Grades for the course will be determined as follows:

40% homework assignments
40% final exam
20% final presentation

For the homework assignments, you are welcome to discuss problems with other students in the class, but you must write up your own solutions independently. There will be approximately 5 homework assignments (one every other week). Assignments will be due in class. Grades for late assignments will be automatically reduced by 50% and a further 10% will be deducted for each day late. Assignments turned in more than five days late will not be graded except under extraordinary circumstances (for illness, a doctor's note will be required). Your lowest assignment grade will not count toward your final course grade, so you will have one pass in case of emergency.

Following the registrar's schedule, the final examination will be on Thursday, Dec. 11, 2014, 12-2 PM in the regular classroom. The final examination will cover material from the entire quarter.

The final presentations will be on applications of the course material. I will provide a list of possible topics later in the term.

Topics to be covered: We will cover topics drawn from: introduction to galaxies; collisionless dynamics and two-body relaxation; gravitational potential theory; stellar orbits; Jeans' equation; virial theorem; dynamical friction; stability of galactic disks; galaxy interactions and collisions; dark matter halos; star clusters; nuclear massive black holes. Time permitting, we will also cover the basics of galaxy formation.