ASTRON 449: Stellar Dynamics (Winter 2017)

This course provides a broad introduction to galaxies and their dynamics, with an emphasis on stellar dynamics. It lays the foundations for research in many areas of Galactic and extragalactic astrophysics.

Instructor: Prof. Claude-André Faucher-Giguère
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Office: Tech F243
Office hour: Thu 1 PM
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 Dearborn 23.

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 textbook, more observationally-oriented.

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

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 particularly useful for current research in Galactic and extragalactic astrophysics.

Course pre-requisites: This 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.

A proper discussion of galaxies will at times require putting them in their cosmological context, so I will assume that you have previously encountered basic elements of cosmology (redshift, critical density, Hubble parameter, ...). The required cosmological background will be fairly minimal, so ASTRON 329/429 is not a pre-requisite. Students who need to brush up on cosmology should study section 1.3 in BT2 ("The cosmological context"). Similarly, some topics covered in the course will 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?) at the level of ASTRON 220.

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

60% homework assignments
40% final exam

For the homework assignments, you are welcome to discuss problems with other students, but you must independently write up your own solutions. There will be 5-6 homework assignments (roughly one every three lectures). Assignments will be due in class. Grades for late assignments will be automatically reduced by 20% 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 (a competing deadline, such as an exam or proposal due, is not an extraordinary circumstance).

The final exam will be a take-home exam. The final will resemble a homework assignment but it will cover the entire term and no collaboration will be allowed. Furthermore, you will have less time to complete it than a regular homework assigment. Details regarding the final will be announced 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 and numerical methods to compute them; Jeans' equation; virial theorem; dynamical friction; stability and formation of galactic disks; galactic star formation; dark matter halos; star clusters; nuclear massive black holes; galaxy interactions and collisions.