Galactic Structure and Dynamics

AST1420

Winter 2017

Professor Hanno Rein

Lecture	Tuesdays, 1pm - 3pm, AB113 - The lectures start prompt at ten past the hour. - Please be on time. - There will be no break (but the lectures will end a few minutes before 3pm).
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Reading/ Bibliography	- Galactic Dynamics, Binney and Tremaine
Assignments	There will be two assignments in this course. Collaboration for these mini-projects is ok, but the write-up must be independent.
Presentations	Every student will have give one 10-15 minutes presentation on a recent paper on this course's topic.
Grading Scheme	There will be a take-home final exam. Neither a calculator nor an equation sheet will be allowed in the exam. The exam will focus on your understanding of the subject, rather then long mathematical calculations.
Grading Scheme	The final grade will be calculated from all assignments, presentations and the final exam. The ratio is as follows:

Assignments	40
Presentation	20
Final exam	40
Total	100

Absences In the case of a problem that supports an absence or an inability to hand in an assignment before the deadline, your grade will be calculated on the basis of all other tutorial work. In the case of a problem that supports the absence to the midterm, your grade will be calculated by increasing the weight of the final exam. Valid and *official supporting documentation* must be submitted within five business days of the missed tutorial or test. It is your responsibility to hand in documentation on time. Failure to do so will impact your grade.

Accessibility Students with diverse learning styles and needs are welcome in this course. In particular, if you have a disability/health consideration that may require accommodations, please feel free to approach me and/or the AccessAbility Services Office as soon as possible. I will work with you and AccessAbility Services to ensure you can achieve your learning goals in this course. Enquiries are confidential. The UTSC AccessAbility Services staff (located in SW302) are available by appointment to assess specific needs, provide referrals and arrange appropriate accommodations (416) 287-7560 or `ability@utsc.utoronto.ca`.

Academic Integrity Academic integrity is one of the cornerstones of the University of Toronto. It is critically important both to maintain our community which honours the values of honesty, trust, respect, fairness and responsibility and to protect you, the students within this community, and the value of the degree towards which you are all working so diligently. Detailed information about how to act with academic integrity, the Code of Behaviour on Academic Matters, and the processes by which allegations of academic misconduct are resolved can be found online: `http://www.artsci.utoronto.ca/osai/students`.

According to Section B of the University of Toronto's Code of Behaviour on Academic Matters (`http://www.governingcouncil.utoronto.ca/policies/behaveac.htm`) which all students are expected to know and respect, it is an offence for students to:

- To use someone else's ideas or words in their own work without acknowledging that those ideas/words are not their own with a citation and quotation marks, i.e. to commit plagiarism.
- To include false, misleading or concocted citations in their work.
- To obtain unauthorized assistance on any assignment.
- To provide unauthorized assistance to another student. This includes showing another student completed work.
- To submit their own work for credit in more than one course without the permission of the instructor.
- To falsify or alter any documentation required by the University. This includes, but is not limited to, doctor's notes.
- To use or possess an unauthorized aid in any test or exam.

Specificlly to this course, please be reminded that you need to understand every solution that you submit. If you work together on an assignment, you still have to be able to present your submission.

There are other offences covered under the Code, but these are by far the most common. Please respect these rules and the values which they protect. Offences against academic integrity will be dealt with according to the procedures outlined in the Code of Behaviour on Academic Matters.

Schedule

- Week 1+2: Observations
  A few astronomical basics such as orders of magnitude in length, time and mass that are important for stellar systems from globular cluster to galaxies and clusters of galaxies. Fundamental observational properties of stars, such as magnitudes and colours in astronomy, Herztsprung-Russell diagrams. Galactic coordinate system and local properties of the galaxy in the solar neighbourhood. A breakdown of components of the galaxy such as disk, buldge, halo. Hubble classification system. Luminosity function, some observational correlations including Schlechter law, Daber-Jackson Law, Kormendy relation, Tully-Fisher law. An estimate for the relaxation time from first principles. Coloumb logarithm.
- Week 3: Potential theory
  General results. Poisson equation. Linearity of differential equations. Divergence theorem and Gauss theorem. Sphereical systems. Newton's first and second theorem. Examples, including point mass, homogeneous sphere, Plummer model, Isochrone potential, NFW model. Potential/density pairs for flattened systems.
- Week 4+5: Orbits
  Complexity of orbits increases as symmetry decreases. Orbits in spherical potentials derived using Lagrangian formalism. Also Hamiltonian formalism. Azimuthal period versus radial period. Special cases of Keplerien potential, spherical harmonic oscillator, iscochrome potential. Constraints and integrals of motion. Constants of motion. Surface of sections and consequents. Implementation in python.
- Week 6+7: Collisionless Boltzmann Equation
  Distribution function. Deriving the Collisionless Boltzmann Equation using Hamilton's equations. Commutator notation. Additional modifications of CBE with borth and death terms. Relationships between distirbution function and observable quantities. Luminosity density, line of sight velocity dispersion, velocity dispersion tensor. Jeans Theorem. Strong Jeans Theorem. Justification of N-body modeling as a MCMC. Softening. Miller instability and chaos. Schwarzschild method.
- Week 8: Equilibria and Stability
  Choice of equilibrium. Principle of maximum entropy. Violent relaxation, mergers. Heat death of the universe. Stability under external perturbations. Tensor Virial Theorem. Shapes of elliptical galaxies, stable solutions to CBE.
- Week 9+10: Numerical methods
  Gravitational two body problem. Non-symplectic integrators, Gauss-Radau methods. High order Taylor series expansion. Adaptive timesteps and error estimation. Hamiltonian formalism, symplectic integrators. Small N systems, Wisdom-Holman integrators. Operator splitting method. Commutators of operators. Machine independent integrators.
- Week 11: Observing session
  Observations at night at the UTSC observatory. Globular clusters, galaxies.
- Week 12: Data analysis
  Analysis of data taken at the observatory. Calibration, calculation of luminosity, fitting plummer model, calculation of number of stars, velocity dispersion.