PHYS 7903/AST 4953 – Galactic Dynamics – Syllabus Spring 2024

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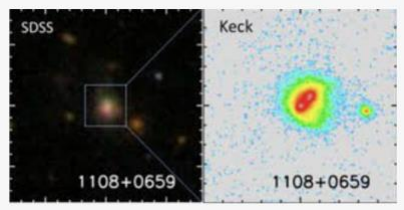
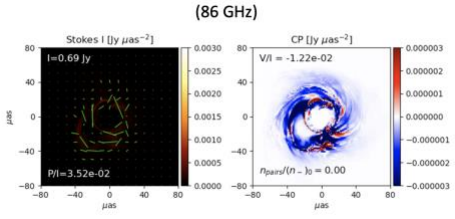


[AGN Binary J1108+0659]

[M87* Polarization Map]



[GRMHD Simulation]

PHYS 7903/AST 4953 Galactic Dynamics

Spring 2024

COURSE INFORMATION

Course Description: A new integrated course for physics and astronomy enthusiasts at UTSA (offered in parallel at UT Austin with the aid of Zoom) investigating galactic dynamics from the largest to smallest scales, including cutting-edge applications such as the Event Horizon Telescope, which gave us the first image of a black hole at the center of the M87 galaxy, whose large scale relativistic jet has been observed since 1918. Since Newton's Philosophae Naturalis Principia Mathematica (1687), the dynamics of galaxies under the gravitational force has emerged as among the best theoretically developed and observationally verified pillars of classical physics. From a simple inverse square law, the gravitational interactions of many bodies in galaxies give rise to a rich panoply of behaviors such as orbits, equilibria, escape and capture. To find analytic solutions, we develop formalisms such as Lagrangian and Hamiltonian mechanics. We also deploy numerical simulations to expand the scope of our analysis, including plasma microphysics of billion-degree plasmas in the vicinity of supermassive black holes. Course topics include potential theory, Lagrangian and Hamiltonian methods, galactic and stellar evolution, compact objects (e.g., white dwarfs, neutron stars, black holes), plasma physics (Vlasov and Fokker-Planck equations, plasma turbulence) and GRMHD equations and simulations.

Course Fees: LRC1 $12; LRS1 $46.20; MEPA $18; STSI $21.60; DL01 $75.
A related course Phys 6123 Magnetohydrodynamics is generally offered: Spring.
Nota bene: This is a Q-rated course satisfying UTSA's Quantitative Scholarship requirement

Credit hours: [3]
Prerequisites/co-requisites: Prerequisite: Graduate standing, PHY 5103 (Classical Mechanics) and PHY 5203 (Electrodynamics), or consent of instructor.
Course Modality: Traditional in-person***+15 min Zoom break*** (confer One Stop Enrollment) M and W 10:00a-11:15a Flawn Building Room 3.02.01. Course registration number 39021/39023

LEARNING GOALS

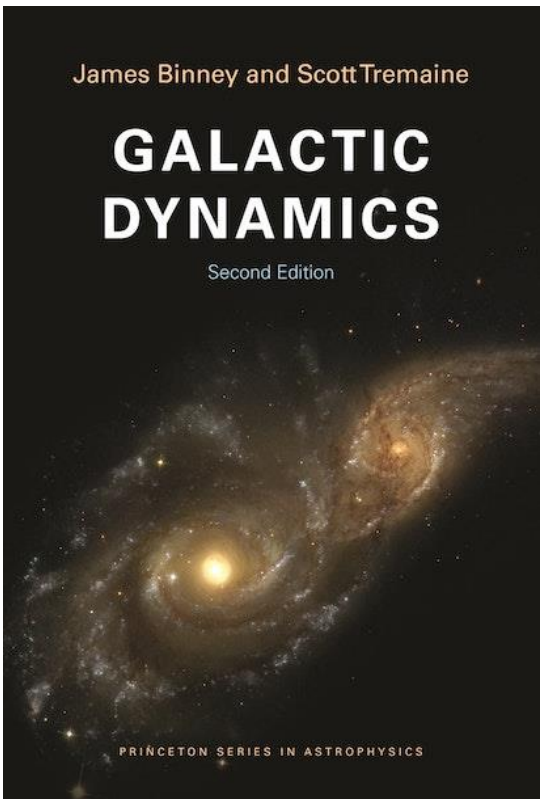
At the end of the course, you will be able to: Identify and interpret crossing and relaxation times for various systems, (e.g., open clusters, globular clusters and galactic centers); solve for dynamics in various potentials (e.g., cylindrically abs spherically symmetric) with various distribution functions, (e.g., Plummer model and Maxwellian distribution). You will also be able to understand their physical consequences, and correct common misconceptions such as a whether stars are likely to collide in galaxy mergers.

The course goals, scaffolded by Bloom's taxonomy, are to: Remember basic postulates and laws of classical mechanics and some methods in functional analysis, e.g., Lagrangian and Hamiltonian methods; Understand stellar and black hole in various systems governed by the gravitational force; Apply our physical knowledge to real-life problems using simulations; Analyze different models in GRMHD libraries of black hole images; Evaluate space policy, such as whether ngEHT should expand by placing antennae in new sites, e.g, Namibia; and Create your own model of routine for postprocessing GRMHD simulations.

COURSE MATERIALS

Required Textbook + Media

Galactic Dynamics



3 hours credit. Prerequisite: Graduate standing, PHY 5103 and PHY 5203, or consent of instructor.

Galactic Dynamics

Galactic Dynamics by James Binney and Scott Tremaine. An option that can be rented cheaply from Amazon is (ISBN-13: 978-0691130279; ISBN-10: 0691130279).

The Unit 1 Materials below are helpful (and free):

Caltech Order of Magnitude Notes

To access this course online

-Login to Canvas

-Go to Coursework

Canvas Support can be found via UTSA Academic Innovation: Phone: **210-458-4520**

ACTIVITIES AND GRADING

How course activities and grades will be assigned and evaluated:

Homework	**45%**
Quizzes 1 and 2	**30%**
Final Presentation	**15%**
Participation	**10%**
Total	**100%**

Grade Distribution and Letter Grade

For this graduate course, I am far more concerned with giving students exposure and experience with the subject than ranking them.

ASSIGNMENT NUMERICAL GRADES WILL BE EVALUATED AND CONVERTED TO LETTER GRADES AS FOLLOWS:

Late homework (submitted after Mon class due dates) will docked 50 percentage points for each week late. Monitor one's grade progress in real time using Blackboard. The numeric-to-letter grade conversion is shown below:

90+% = GRADE A

80%-89% = GRADE B

<80% = WE'LL TALK ABOUT IT

ESSENTIAL STUDENT INFORMATION

- **Important:** Bookmark and visit the Common Syllabus Information webpage to find important and valuable resources about counseling services, transitory/minor medical issues, supplemental instruction, tutoring services, academic success coaching, sexual harassment and sexual misconduct, campus safety and emergency preparedness, inclusivity statement, and the Roadrunner Creed.
- For technical requirements, support, and academic resources, visit the Student Support Gateway, where you can find all your tech and academic support resources in one place.
- Follow Online Learning Netiquette standards for your online communication activities. Please be mindful of the communication tools available in your course and use them for learning purposes. Class discussions take place in a respectful and safe environment, whether online or in person. UTSA encourages everyone to openly share their ideas and opinions without penalty or judgment, but learning should always be based on facts and research. It is possible to disagree without being disagreeable.
- UTSA provides reasonable accommodations to students via the Student Disability Services. For more details on eligibility, policies, and requirements, please visit www.utsa.edu/disability or call (210) 458-4157.
- **UTSA Wellbeing Resources:** your wellbeing is a priority for us. UTSA is proud to partner with Wellness 360 and MySSP to provide students with access to quality health and mental health care. Visit the UTSA Students Wellbeing Resources to explore the services available.

INSTRUCTOR CONTACT INFORMATION

Instructor Name: **Prof. Richard Anantua**

Department and College: Department of Physics & Astronomy

Office Location: **AET 3.386 or Zoom**

Student hours: Th 1p-2p via Zoom *(email for appointment)*

Phone Numbers: **(210) 458-6564**

Email Address: **richard.anantua@utsa.edu**

COMMUNICATION PLAN

There are several ways you can communicate with me.

My preferred method of communication is:

- **Email, you may email me at richard.anantua@utsa.edu. You may also use the Send Email tool in Canvas.**
- **Course Messages tool in Canvas, in case you need to send me a private message, for example, about a grade. This communication stays on Canvas and is the only secure way to discuss your grade. You must log in to Canvas to send and receive a course message.**
- **Post questions in the Course Q&A forum in Canvas. This is a public forum provided for content and course-related questions. I encourage you to participate in this forum to get involved with your class.**

Don't hesitate to contact me and join the Student Support Hours

About Me

Richard Anantua: I am a UTSA Assistant Professor excited to be part of your academic journey this semester. Galactic Dynamics is a new course here— and will thus be a learning experience for me and you.

My current research focuses on reverse engineering near-horizon supermassive black hole observations from intercontinental baselines of radio telescopes –primarily the Event Horizon Telescope (EHT)– using a methodology I call "Observing" Jet/Accretion flow/Black hole (JAB) Simulations. I lead the first EHT research group in Texas, primarily conducting research within the EHT Theory and Simulations Working Group. I also lead the EHT Outreach Group for the Americas, and have established nexuses between EHT and networks supporting diversity in the sciences such the NSBP/SAO EHT Scholars program.

My broad research interests have included: theoretical cosmology, high-energy theoretical astrophysics (e.g., Blandford-Znajek jets from supermassive black holes), high-energy theoretical particle physics (e.g., string theory [especially AdS/CFT correspondence]), condensed matter theory (e.g., strongly correlated fermionic systems with holographic dual).

My degrees are as follows:

Ph.D. in Physics; Stanford University 2016
Ed.M. in Education Policy and Management; Harvard University 2014
M.S. in Physics; Stanford University 2013
B.S. in Physics and Philosophy and B.S. in Economics and Mathematics; Yale University 2010

My Teaching Philosophy

My teaching philosophy can be found in this statement.

My Inclusivity Philosophy

The University of Texas at San Antonio, a Hispanic Serving Institution situated in a global city that has been a crossroads of peoples and cultures for centuries, values diversity and inclusion in all aspects of university life. As an institution expressly founded to advance the education of Mexican Americans and other underserved communities, our university is committed to ending generations of discrimination and inequity. UTSA, a premier public research university, fosters academic excellence through a community of dialogue, discovery, and innovation that embraces the uniqueness of each voice.

I have devoted much of my academic career to diversity and inclusion. Focusing on skills- and training-based initiatives as the key to leveling the educational playing field, I have started the NSBP/SAO EHT Scholars and UTSA-EHT Scholars and launch the next generation of diverse leaders. I look forward to championing and advocating for all my students.

ASSESSMENTS AND ASSIGNMENTS

Description of major assignments and assessments.

- Homework: We have a homework assignment or quiz assessment due Mon 10a each week starting Mon Jan 29, 2024 ending Mon Apr 22, 2024 to support student success.
- Quizzes: We will have two quizzes complementing the homework. Research suggests early, frequent “low-stakes” assessment activities produce better outcomes. Refer to HOP Class Attendance and Policies for more details.
- Exams: This course will have Quizzes Feb. 26, 2024 and Mar. 25, 2024. There will be no final exam, rather a final presentation Apr. 29 and May 1.
- Participation: To support student success, this course will incorporate “active learning” assignments. Research shows that hands-on, applied, collaborative, problem-based, and context-relevant assignments engage students and produce better outcomes.

COURSE SCHEDULE

For a list of important university-wide dates, review One Stop's academic calendar. In particular, for Spring 2024, some key dates are:

Spring 2024 Key Dates

Nota bene: There is a weekly **homework or assessment typically due in class Mon** from Jan. 29 to Apr. 22— with two presentation dates. There will be 3 blocks of 1-2 homeworks followed by an oral or written assessment, with **Quiz 1 due on 2/26/24, Quiz 2 on 3/25/24 and Final Presentations on 4/29/24 and 5/1/24**.

W Jan 17 – First Day of Class 10:00a-11:15a

M Jan 22 – **HW 0** Introduce yourself – email richard.anantua@utsa.edu and gebhardt@astro.as.utexas.edu your academic background (especially experience related to mechanics and mathematical analysis), expectations and what you hope to get from this course

M Jan 29 – **HW 1** due in class

M Feb 12 – **HW 2** due in class

M Feb 26 – **Midterm Quiz 1** (take home) due 1p

M Mar 4 Midterm Grades Due

M Mar 11 – F Mar 15 – **Spring Break**

M Mar 18 – **HW 3**

M Mar 25 – **Midterm Quiz 2** (in class)

M Apr 8 – **HW 4; I-35 Eclipse!**

M Apr 22 – **HW 5**

M Apr 29 – **Final Presentations** in class; Last Day of Class for UT

W May 1 - **Final Presentations** (cont.); Last Day of Class for UTSA

M May 13 – Final Course Grades Due on ASAP

Topic/Module List

The course will be subdivided into:

Unit 0: Introduction – Ch. 1

Unit 1: Fundamentals of Astronomy – Chs. *1*,2

Unit 2: Shapes of Galaxies and Deprojections – Chs. *2*,6

Unit 3: Mechanics of Galaxy Formation – Chs. 4,5,7,9

Unit 4: Dynamical Models – Chs. 3,*4*

Unit 5: GRMHD and AGN Feedback – Ch. *9*

Unit 6: Cosmology and the Expanding Universe – Ch. *1*

COURSE MANAGEMENT AND POLICIES

Instructor-Initiated Drops

This course uses instructor-initiated drops for students who exceed the absence and/or missed assignment limit. Therefore, up to the last day for students to withdraw from an individual course, [3/25], you will be dropped for exceeding [10 absences or receiving and average of 50% or lower on assignments]. Students will receive at least one courtesy warning when approaching the absence/missed assignment limit. Notification will be sent via ASAP to the student's email address. A subsequent absence or missed assignment will result in being dropped from the course. Notification of being dropped will also be sent via ASAP to the student's email address. *This drop does not affect enrollment in other courses.* **Please consult the Dropping Courses webpage** for further details on the process and appeals.

Student Code of Conduct and Scholastic Dishonesty

The Student Code of Conduct is Section B of the Appendices in the Student Information Bulletin. Scholastic Dishonesty is listed in the Student Code of Conduct (Sec. B of the Appendices) under Sec. 203.

Copyright and Fair Use

It is important to understand the issue of intellectual property rights. You may not use the images or thoughts of others for profit or gain without their written permission. The UTSA library has a Copyright Laws and Public Performance Rights (PPR) page.

Students with Disabilities
The University of Texas at San Antonio, in compliance with the Americans with Disabilities Act and Section 504 of the Rehabilitation Act, provides "reasonable accommodations" to students with disabilities. Only those students who have officially registered with Student Disability Services and requested accommodations for this course will be eligible for disability accommodations. Instructors at UTSA must be provided official notification of accommodation through Student Disability Services. Information regarding diagnostic criteria and policies for obtaining disability-based academic accommodations can be found at www.utsa.edu/disability or by calling Student Disability Services at (210) 458-4157. Accommodations are not retroactive.

Family Educational Rights and Privacy Act (FERPA)
FERPA grants students the right to control certain disclosures of their educational records. For a full explanation of your rights and to grant access to FERPA educational records, go to Student Catalog Annual FERPA Letter and One Stop Enrollment – FERPA Proxy Access. Without your consent or authorization of proxy access, UTSA may release Directory Information, such as but not limited to your name, email, phone, place of birth, and photograph, unless you have opted out of the release of Directory Information. To opt out, go to Restrict Directory Information Form. ***Mandatory Reporting of Sexual Misconduct and Reporting of Health and Safety Information***: If a student discloses an incident of sexual misconduct to any UTSA employee (other than to a designated confidential employee such as mental health counselor or PEACE advocate, a UTSA police officer using a pseudonym form or at a public awareness event), that information is not confidential, and the UTSA employee must report all known information to the UTSA Office of Equal Opportunity Services. Employees may also report any concerns about the health and safety of students or others to other school officials and/or law enforcement. For a complete list of exceptions to FERPA, please see Student Catalog Annual FERPA Letter and HOP 5.01.

Video and audio recording
As the instructor of this course, I may record meetings and lessons. You are expected to follow appropriate University policies and maintain the security of passwords used to access recorded lectures. Recordings may not be published, reproduced, or shared with those not in the class. If the instructor or a UTSA office plans any other uses for the recordings, consent of the students identifiable in the recordings is required before such use unless an exception is allowed by law. For more information on your privacy and class recordings, review Student Privacy (FERPA) in Virtual Classrooms and Other Educational Recordings and the Guide to Secure Video Conferencing Tools.

Note: The syllabus is subject to change at the instructor's discretion. Any changes/corrections to the course materials, assignment dates, or other updates will be communicated to the students ahead of time. You are responsible for checking Blackboard for corrections or updates to the syllabus.