

# Physics 4001 Cosmology & Galaxies

Spring 2024

Version 0.0

Last Updated on 1/8/2024

## Goal

A broad introduction to the physics of galaxies and cosmology. Upon completing this course, the successful student will have an adequate comprehension of the basics of modern observational cosmology.

## Instructor

**Dr. Shun Saito**

Office: Physics 106

Office hours: 8:00-9:30am on Tuesday & Thursday or set up an appointment via email

Email: [saitos@mst.edu](mailto:saitos@mst.edu)

## Meeting time and location

Tuesday and Thursday, 9:30pm-10:45pm@Physics 127

All the communication including announcements, course material, assignment submissions, and grade records will be available **on One Canvas**. Please make sure that everyone can regularly check the course website on Canvas.

## Prerequisites

Physics 2305 “Introduction to Modern Physics” or Physics 2311.

The entire course is designed to be almost self-contained, though. If you have any issues or difficulties to follow the course material, please feel free to contact the instructor.

## Textbook

Required:

1) **Dan Maoz “Astrophysics in a Nutshell (Second Edition)”**

Princeton University Press. Hardcover.

ISBN-13: 978-0691164793, ISBN-10: 0691164797

Supplements:

2) Barbara Ryden “Introduction to Cosmology (Second Edition)”

Cambridge University Press. Hardcover.

ISBN-13: 978-1107154834, ISBN-10: 1107154839

3) Bradley W. Carroll and Dale A. Ostlie “An Introduction to Modern Astrophysics”

Cambridge University Press. Hardcover.

ISBN-13: 978-0805304022, ISBN-10: 0805304029

4) Daniel Baumann “Cosmology”

Cambridge University Press. Hardcover.

ISBN-13: 978-1108838078

5) Houjin Mo et al. “Galaxy Formation and Evolution”

Cambridge University Press. Hardcover.

ISBN-13: 978-0521857932, ISBN-10: 0521857937

## Class Structure

On Tuesday, a class will consist of a simple blackboard lecture. At the end of every Thursday lecture, a group of a few students are required to lead a discussion on a topic related to materials covered in the same week for about 15 minutes.

## Homework

Problem sets will be due every week (except for the first week and post-exam weeks) at **9:30am on Tuesday**. Homework will be collected electronically in a form of **PDF file on Canvas**. Each homework will be graded on Canvas with **maximum of 40 points**. **Any late submission without a pre-approval is subject to a 5-point subtraction**. The minimum two scores out of 12 submissions will be dropped.

## Presentation

As mentioned above, there will be a 15-minute presentation at the end of each Thursday lecture. A group of students will be assigned by the instructor one week in advance, and may choose a topic related to materials covered in the previous week. The topic should be approved by the instructor by Tuesday in the same week. Presentation slides should be turned in on Canvas before the beginning of the Thursday class.

## Exam

We will have two **interview exams** in the week of March 1st and the final week.

\* Why not a written exam?

I believe that it is inefficient to assess students learning for an advanced course like this kind with a written exam under the time pressure. This is simply because we have no situation like a written exam in our daily research environment. A live discussion in an in-person meeting is crucial and essential.

\* How does it work?

The instructor will distribute a set of example questions by Tuesday class in the previous week. Thursday class in the previous week will be devoted to reviewing the example questions. A student is required to set up a 30-minute appointment to meet the instructor during the exam weeks. A student will answer to the questions which the instructor asks there where the student can access any material.

## Grading

A  $\geq$  895, B  $\geq$  795, C  $\geq$  695, D  $\geq$  595 for 1000 total points whose break down is following:

Homework	400
Presentation	300
Mid-term Exam	150
Final Exam	150
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Total	1000

## **Course attendance policy**

Students are required to attend all classes. Please do not arrive late to class or leave early unless you have been previously excused by the instructor. Of course, if you are taken ill during class, or in case of an emergency, feel free to leave. However, as soon as you feel better, or the emergency is over, let the instructor know the reason why you left. The instructor will not solicit details of the occurrence, or any personal or private information. Students with inadequate attendance may be dropped. Any student who has inadequate attendance, as evidenced by 5 (five) confirmed absences or by missing a total of 5 (five) graded assignments of any kind (exams and homework) are subject to being dropped if a subsequent class or assignment is missed. The University requires that all students have their course attendance verified at least once during the first two weeks of the semester. If your attendance is not verified, then you will be dropped from the course and any financial aid will be adjusted accordingly.

In case you are/may be exposed to COVID-19, please follow [the university guideline](#). Please notify the instructor as soon as you expect to be absent in a class due to sickness. If it involves multiple students particularly for COVID-19, the instructor will flexibly deal with an individual case.

## **Statement about Copyright, FERPA, and Use of Video**

It is vitally important that our classroom environment promote the respectful exchange of ideas. This entails being sensitive to the views and beliefs expressed during discussions, whether in class or online. Please obtain instructor permission before recording any class activity. It is a violation of University of Missouri policy to distribute such recordings without authorization and the permission of all who are recorded. More information is provided [online](#).

## **Accessibility and Accommodations**

It is the university's goal that learning experiences be as accessible as possible. Student Accessibility and Testing provides services and accommodations that facilitate full participation in Missouri S&T's learning experience for students with disabilities. If you anticipate or experience physical, academic, and/or digital barriers due to a disability, please contact Student Accessibility and Testing at (573) 341-6655, email [dss@mst.edu](mailto:dss@mst.edu), or visit <https://saat.mst.edu/> for information.

## **Student Honor Code and Academic Integrity**

- All students are expected to follow the [Honor Code](#).
- [Student Academic Regulations](#) describes the student standard of conduct relative to the University of Missouri System's Collected Rules and Regulations section 200.010, and offers descriptions of academic dishonesty including cheating, plagiarism, sabotage, and **unauthorized use of artificially generated content**, any of which will be reported to the Vice Provost for Undergraduate Education.
- Other resources for students regarding academic integrity can be found [online](#).

## **Student Well-Being**

Your well-being is important, and it contributes to your success in this course. At S&T, we provide resources to support your mental, physical, and social well-being. Any of us can experience challenges that make learning difficult. If you are struggling, take advantage of the following resources offered by the university:

### **Student Well-Being**

Student Well-Being provides counseling services, health promotion initiatives, and prevention programs to empower the S&T community to thrive and enhance personal, academic, and professional success. Department office hours are Monday-Friday, 8 a.m. – 5:00 p.m. On the website, you can find information related to confidential individual and group counseling, wellness consultations and trainings, resources for many health and wellness topics, and help for mental health crisis situations.

For the National Suicide Prevention Lifeline, call or text 988, or visit [missouri988.org](https://missouri988.org).

### **Health and Well-Being Canvas Course**

The Health and Well-Being Canvas Course features trainings, presentations, and other health and well-being resources for students. The course is free for all students, is non-credit, and students can enroll at any point in the semester.

[Student Support and Community Standards](#) is your “Google Maps” for support. During your time at S&T, you or a friend may need help navigating their student experience, facing a barrier, or experiencing a challenge. You are not alone!

Student Support has a dedicated team and numerous resources such as [UCARE](#) and the [student emergency fund](#) to help you navigate the S&T experience and support your success. This includes support to address barriers related to academic, personal, emotional,

medical, financial, or any other needs. All students can learn and grow from challenges or setbacks, they are stepping stones to success and we are here to help.

## **Nondiscrimination, Equity, and Title IX**

Missouri S&T is committed to the safety and well-being of our campus community, and to creating an environment free from discrimination and harassment.

The University prohibits discrimination and harassment on the basis of race, color, national origin, ancestry, religion, sex, pregnancy, sexual orientation, gender identity, gender expression, age, disability, protected veteran status, and any other status protected by applicable state or federal law. As used in this policy, the word “sex” is also inclusive of the term “gender.”

Additionally, US Federal Law Title IX states that no member of the university community shall, on the basis of sex, be excluded from participation in, or be denied benefits of, or be subjected to discrimination under any education program or activity. Sexual harassment violations of this law include quid pro quo, hostile environment, sexual assault, dating/ domestic violence, and stalking. The U.S. Department of Education has stated the prohibition on discrimination on the basis of sex includes sexual orientation and gender identity.

Students who are experiencing pregnancy or pregnancy-related conditions, including the birthing parent and non-birthing parent, have rights protected under Title IX. Students should contact the Office of Equity and Title IX to learn more about their rights and pregnancy-related assistance/accommodations provided by the University to ensure equitable access to University educational programs and activities.

In accordance with the University of Missouri’s Collected Rules and Regulations, all faculty and staff are required to report any information concerning discrimination disclosed through communication including, but not limited to, direct conversation, email, social media, classroom papers and homework exercises to the Equity Officer/Title IX Coordinator.

For more information regarding support for those that have been impacted or to report an incident of discrimination or harassment as defined by [Chapter 600](#) of the University’s Collected Rules and Regulations, visit the Office of Equity and Title IX or visit their website at [equity.mst.edu](http://equity.mst.edu).

## **Office of Equity and Title IX**

Equity Officer and Title IX Coordinator: Dr. Paul Hirtz

Phone: (573) 341-7734

Location: 900 Innovation Drive, Suite 500

E-mail: [equity@mst.edu](mailto:equity@mst.edu)

## **Classroom Egress Maps**

For all in-person instruction, faculty should explain where the classroom emergency exits are located. Classroom egress maps are posted at <http://designconstruction.mst.edu/floorplan/>.

## **Learning Assistance through LEAD**

The Learning Enhancement Across Disciplines (LEAD) program runs Learning Centers and Tutoring which provide an efficient means to improve your understanding and increase your mastery of the material you are studying. Discipline-based faculty and undergrad peer instructors operate open-environment learning centers in nearly every foundational course as well as many upper-level courses. See the schedule for LEAD learning assistance at <https://lead.mst.edu/schedule/>.

## **Writing and Communication Center**

The Writing and Communication Center's mission is to assist all students in their efforts to become better writers, communicators, and critical thinkers. The Center's peer consultants and coaches provide free individualized one-on-one and small-group conversations to offer meaningful feedback and guidance to students across all disciplines. More information can be found on our website, through email: [writing@mst.edu](mailto:writing@mst.edu) or stop by Curtis Laws Wilson Library 314-315.

## **Student Success Center**

The Student Success Center (SSC) supports student development through peer Academic Mentoring focusing primarily on STEM courses, peer-to-peer soft skill coaching which can also act as an accountability buddy, and campus programming – all while providing free coffee and hot beverages! All undergraduate students are encouraged to utilize the SSC's free services to get timely support and to enhance their S&T Miner Experience. Contact us at [success@mst.edu](mailto:success@mst.edu) OR 573-341-7590. To see the course offerings and times for SSC Academic Mentoring, visit <https://studentsuccess.mst.edu/academicmentoring/>.

## **Knack Tutoring**

Enrolled S&T undergraduate students can receive complimentary **FREE** tutoring assistance from peers who have successfully completed the course, available round the clock. You have

the option to connect via the Knack platform online or in person on campus. If you've excelled in a course, consider becoming a Knack Tutor to support your fellow Miners!

## **Student Veterans Resource Center**

The Student Veterans Resource Center (SVRC) is the nexus of resources and support for student veterans at S&T. The SVRC provides student veterans with a “safe space” and a familiar atmosphere. The center’s Veteran Consuls provide one-on-one consultations to guide students to various resources on campus, while its advisor provides students with VA health and benefits resources. Visit the SVRC at Harris Hall, Suite G10, and contact us at [svrc@mst.edu](mailto:svrc@mst.edu).

## **Changes to syllabus**

If a revision of the syllabus becomes necessary during the semester, it will be discussed in a class. Any changes to the syllabus will be posted on Canvas.

## **Statement of agreement**

Please carefully review and print for your records this syllabus. By taking this class, you confirm you have read and understood this document and are agreeable to the policies and provisions set forth therein.

# Schedule

\* Saito will be away on **the dates highlighted in red color** when there will be no live lecture. Instead pre-recorded lectures will be made available on Canvas.

#	Date	Contents	Homework due	Presentation
1	Tue, 1/16	Introduction		
2	Thu, 1/18	Observations Basics		P-Example
3	Tue, 1/23	Stars - Basic Observations	HW-1	
4	Thu, 1/25	Structure of the Milky Way		P-1
5	Tue, 1/30	Structure of the Milky Way - Dark Matter	HW-2	
6	Thu, 2/1	Structure of the Milky Way - Microlensing		P-2
7	Tue, 2/6	Galaxy Formation Theory	HW-3	
8	Thu, 2/8	Star Formation and Interstellar medium		P-3
9	<b>Tue, 2/13</b>	Galaxy Demographics	HW-4	
10	<b>Thu, 2/15</b>	AGNs, QSOs and SMBHs		
11	<b>Tue, 2/20</b>	AGNs, QSOs and SMBHs	HW-5	
12	Thu, 2/22	Galaxy Groups and Clusters		P-4
13	Tue, 2/27	(Reserved for adjustment)	HW-6	
14	Thu, 2/29	Review for Mid-term Exam		P-5
<b>ME</b>	3/1 - 3/8	<b>Mid-term Interview Exam</b>		
15	Tue, 3/5	Basic cosmology, distances		
16	Thu, 3/7	Basic cosmology, distances, Hubble's law		
17	<b>Tue, 3/12</b>	Friedmann equations	HW-7	
	Thu, 3/14	No lecture (Spring Recess)		
18	Tue, 3/19	Cosmological models	HW-8	
19	Thu, 3/21	Cosmological models		P-6
	Tue, 3/26	No lecture (Spring Break)		
	Thu, 3/28	No lecture (Spring Break)		
20	Tue, 4/2	Cosmic Microwave Background	HW-9	
21	Thu, 4/4	Cosmic Microwave Background Anisotropy		P-7

#	Date	Contents	Homework due	Presentation
22	Tue, 4/9	Big Bang Nucleosynthesis	HW-10	
23	Thu, 4/11	Inflation		P-8
24	Tue, 4/16	Structure formation	HW-11	
25	Thu, 4/18	Baryon Acoustic Oscillations		P-9
26	Tue, 4/23	Weak lensing	HW-12	
27	Thu, 4/25	Lyman-alpha forest		P-10
28	Tue, 4/30	(Reserved for adjustment)	HW-13*	
29	Thu, 5/2	Review for Final Exam		P-11*
<b>FE</b>	5/6 - 5/10	<b>Final Interview Exam</b>		