



Course ID: ASTR-499

Title: Cosmic Discoveries from Galileo to the Present Time

Units: 4 – Spring 2023

Term—Day—Time: Maymester MTWThF 9:30am-12:30pm (first week at USC), various times (Florence)

Location: USC (1.5 weeks, 18 instructional hours), Florence (approximately 28 hrs)

Instructor: Elena Pierpaoli

Office: SHS 371

Office Hours: at students' request

Contact Info: pierpaol@usc.edu

Faculty Accompanying Students: Elena Pierpaoli

Contact Info: pierpaol@usc.edu

Timeline for replying to emails: within 48 hours

Visits:

LIGO prototype (at Caltech - Pasadena)

Mt Wilson – Engineering special tour (Pasadena)

VIRGO experiment (near Florence)

Galileo Museum (Florence)

Firenze Observatory and Galileo house (Florence)

Pisa main square guided tour (near Florence)

NB: the visit schedule might change as all locations reserve to assess COVID risks at a later time.

Special lecturers:

Dr. Michele Vallisneri (JPL, Gravitational Waves)

Prof. Vahe Perroomian (USC, Galileo and the History of Astronomy)

Prof. Rana Adikari (Caltech, LIGO tour and explanation)

Dr. Silvia Tomasi (Pisa)

Special guests (Q&A with the authors of the books):

Dr. Mario Livio

Course Description

This course is most appropriate for junior and senior students in the physical and astronomical sciences as well as in engineering. Students in other scientific fields showing great achievements in connecting different scientific topics will also be considered.

The course will present our current knowledge of the Universe, explaining how our understanding came to be and how different observations shaped it, from the era of Galileo to the present time. We will link the scientific breakthroughs that Galileo has brought to the human kind with his living and working context, including the artistic and architectural surroundings.

We will discuss current frontiers where astronomy meets fundamental physics, and how physical discoveries are possible with astronomical observations of the cosmos.

We will also discuss the new era of extragalactic astronomy that we are entering, in which not only we can observe light coming from the cosmos with new and powerful telescopes, but also we can detect and study gravitational waves with ground and space based impressive instrumentation.

Learning Objectives and Outcomes

On completion of the course, students should be able to:

- Describe Galileo's contributions to the human kind, and connect it with the environment he was living in, and the scientific, philosophical and religious debated of that period.
- Describe how our understanding of the Universe has evolved from Galileo's time to now.
- Describe our current understanding of the universe, including the components of the standard cosmological model and the characteristics of the Universe's expansion.
- Discuss the evidences for the existence of the various energy components of the Universe, and describe how astrophysical observations can characterize them.
- Discuss what are gravitational waves, how we measure them, and which are the possible astrophysical sources for them.
- Describe how gravitational waves' studies can complement the information we deduce from the study of luminous objects in the cosmos.

Additional general objectives are:

Develop skills for communication of scientific concepts, develop the ability to connect apparently distant fields, be able to perform a critical reading of a scientific text, and improve problem-solving skills.

Prerequisite(s): students must have completed one of these three classes: PHYS152, PHYS162, or PHYS 172

Recommended Preparation: Students would benefit from some knowledge of the material covered in PHYS163. However, the necessary material can be covered in class.

No prior Astronomy knowledge is required. Natural curiosity for various aspects of the scientific undertaking, spanning from philosophical questions to sophisticated instrumentations, to aspects of life that determine the scientific outcomes in given historical moments, would greatly enhance the student's experience in this course.

Course Notes: Lectures will mainly be standard blackboard lectures with exercises. However, slides, images and videos will be used when appropriate. In such case, they will be made available to the students via a shared drive. Students are expected to take their own hand-written notes. Students will need computer access and standard software to access the slides and images/videos in order to study.

Homework policy: There will be 4 homework assignments during the course. Assignments may consist in standard exercises on what explained in class, as well as targeted questions following the visits to the sites of interest (so: you should pay attention!). Each homework will be 3%-4% of your final grade.

Participation and attendance: Participation in the classroom and during the visits is perhaps the most important element of the education this class offers. I will expect each student to actively participate in the course by either asking questions or contributing to discussions. Arriving late and/or leaving early will also affect your participation grade in the course.

For the overseas portion of the course, attendance at the daily classes and excursions is mandatory. Grading is assigned for attendance (see below).

Required Readings and Supplementary Materials

We will make use of these two books, both available in electronic version in the USC library:

- 1) "Extragalactic Astronomy and Cosmology" by Peter Schneider (Springer, Jan 2015)
- 2) "An Introduction to Modern Cosmology", by Andrew Liddle, Wiley, third edition (2015)

One book will be required to be read before the course starts (and likely before April 1st). These are:

- 1) Mario Livio "Galileo and the science deniers" (2020)

Other potentially interesting books (not necessary for the course) are:

- 1) Dava Sobel "Galileo's Daughter: A Historical Memoir of Science, Faith and love"
- 2) Janna Levin "Black Hole Survival Guide" (2020)
- 3) Janna Levin "Black Hole Blues and other Songs from outer Space" (2016)
- 4) Jed Buchwald "Einstein was right: The science and history of gravitational waves" (2020)
- 5) Pierre Binetruy "Gravity!: The quest for gravitational waves" (2018)

We will supplement this material with various readings linked to the blackboard webpage. Videos will also be assigned to be viewed either before or during the course.

Description and Assessment of Assignments

Homework will consist of: a) exercises on the topics covered in class; b) learning from internet searches on some specific topic loosely discussed in class, c) summary of the main learning points of visits made,

d) summary of books and book discussions.

The work will be assessed for completeness, clarity, and demonstrated ability to connect the various topics.

Each homework will count as $\frac{1}{4}$ of the total homework grade.

Grading Breakdown

Grading type will be letter grade.

15% participation and attendance

35% Midterm

35% final exam

15% homework (4 sets of exercises/questions)

Each day of (unexcused) absence during the overseas portion of the trip will imply a 5% cut in your final grade. After 3 days of absence you won't get any credit for participation/attendance. If you are sick or cannot be present for any other reason, please contact the instructor as soon as possible, in order to be excused. In most cases, documentation regarding your requested excuse will be needed.

Grading Timeline

Homework will be corrected within 3 working days from submission.

Grading Scale

Course final grades will be determined using the following scale

A	95-100
A-	90-94
B+	87-89
B	83-86
B-	80-82
C+	77-79
C	73-76
C-	70-72
D+	67-69
D	63-66
D-	60-62
F	59 and below

Assignment Submission Policy

Homework will be assigned 3 days before it is due. It needs to be returned in class.

Additional Policies

Late assignments will not be graded.

Personal electronic communication devices (phones and similar) must be turned off or placed away during lectures and visits. Likewise, you should not use instant messenger or similar chat programs during lectures.

No late exams will be accepted or arranged. For -very- serious (and proved) health related reasons, special arrangement may be done to make the exam on a different date. Exam dates are provided at this time.

You may use a simple (non-programmable) calculator during the exam.

The exam will be closed books.

You may produce your own one-page cheat sheet to bring to the exam.

Course Schedule: A Weekly Breakdown

Two meetings will be scheduled during the standard spring semester (sometimes in April) to discuss the book you are supposed to read before class starts. These will be arranged considering the enrolled student's schedule. One meeting will also serve as an introduction to the course, and preparation for the (busy) Los Angeles week.

During one of the two meetings, we will have a Q&A session with the author (Dr. Livio).

Week 1: USC (May 22-26 APPROXIMATE schedule, to be confirmed later in the year)

- DAY 1: The current cosmological model [1.5 hrs lecture]
- DAY 1: Structures in the Universe and their observations [1.5 hrs lecture]
- DAY 2: Introduction to gravitational waves [3 hrs by Michele Vallisneri]
- DAY 3: LIGO prototype visit at Caltech [1 hr guided tour by Prof. Rana Adhikari, Q&A]
 - First homework assigned

- DAY 4: Mt Wilson visit [NOTE: full day: 9 am - 3 pm guided "engineering" tour]
- DAY 5: Astronomy: an historical perspective [1.5 hrs of lecture, lecturer: Vahe Perroomian]
- DAY 5: Galileo: an introduction [1.5 hrs of lecture, lecturer: Vahe Perroomian]
 - Second homework assigned

**Memorial Day Holiday, Monday, May 29*

Travel Days, Tuesday/Wednesday, May 30 & 31, 2023

Week 2 and 3: Florence (June 1-15, lectures held at the Eurocentres – InFlorence Academy)

- JUNE 1: Welcome to Florence; Galileo: life and contributions to the human kind [3 hrs lecture]
- JUNE 2: Galileo in Pisa: visit to Pisa square and surroundings: following Galileo footsteps [all day, 5 hrs, visit guide: Dr. Silvia Tomasi]
- JUNE 5: Visit to the Galileo museum [1 hr guided tour plus 1 hr independent tour]
 - Third homework assigned
- JUNE 6: Visit to the Firenze Observatory and Galileo house [2+1 hrs, Observatory: Simone Bianchi, Andrea Tozzi]
- JUNE 7: First midterm (1.5 hrs)
- JUNE 8: Open questions in modern cosmology: dark matter, dark energy and inflation [3 hrs]

- JUNE 9: Gravitational waves: sources of (Inflation, stellar-mass black holes, supermassive black holes) [1.5 hrs] , Gravitational waves and the Cosmic Microwave Background [1.5 hrs]
 - Fourth homework assigned
- JUNE 12: connecting the pieces in modern cosmology: complementarity between galaxy/CMB surveys and gravitational waves observations [3hrs]
- JUNE13: Visit to VIRGO – a real gravitational wave detector [visit guide : Dr.Valerio Boschi]
- JUNE 14: Course summary, course evaluation [3 hrs]
- JUNE 15: Final exam [3 hrs]

Transportation

Student airfare can be secured by USC and billed to the student account. Students are also permitted to book their own as a personal expense but are required to submit their itinerary through Terra Dotta prior to travel. Students are highly encouraged to purchase refundable tickets and/or travel insurance as Dornsife is not obligated to cover airfare that was not booked through our preferred USC travel vendor.

USC will provide local travel around the Pasadena area.

Prof. Pierpaoli, assisted by Florence Academy, will take care of transportation arrangements within Florence.

Lodging

Students will be in shared apartments of 4-6 people in Florence, very close to the school, in the center of the city.

Cost

This is not yet determined. Once obtained, students can use the estimator on the [ASTR-499 Maymester page](#) under the Costs tab to get an idea of an overall amount. Note: The \$500 fee is only charged if a student withdraws after the commitment date.

Academic Integrity

The University of Southern California is foremost a learning community committed to fostering successful scholars and researchers dedicated to the pursuit of knowledge and the transmission of ideas. Academic misconduct is in contrast to the university's mission to educate students through a broad array of first-rank academic, professional, and extracurricular programs and includes any act of dishonesty in the submission of academic work (either in draft or final form).

This course will follow the expectations for academic integrity as stated in the [USC Student Handbook](#). All students are expected to submit assignments that are original work and prepared specifically for the course/section in this academic term. You may not submit work written by others or "recycle" work prepared for other courses without obtaining written permission from the instructor(s). Students suspected of engaging in academic misconduct will be reported to the Office of Academic Integrity.

Other violations of academic misconduct include, but are not limited to, cheating, plagiarism, fabrication (e.g., falsifying data), knowingly assisting others in acts of academic dishonesty, and any act that gains or is intended to gain an unfair academic advantage.

The impact of academic dishonesty is far-reaching and is considered a serious offense against the university and could result in outcomes such as failure on the assignment, failure in the course, suspension, or even expulsion from the university.

For more information about academic integrity see the [student handbook](#) or the [Office of Academic Integrity's website](#), and university policies on [Research and Scholarship Misconduct](#)

Course Content Distribution and Synchronous Session Recordings Policies

USC has policies that prohibit recording and distribution of any synchronous and asynchronous course content outside of the learning environment.

Recording a university class without the express permission of the instructor and announcement to the class, or unless conducted pursuant to an Office of Student Accessibility Services (OSAS) accommodation. Recording can inhibit free discussion in the future, and thus infringe on the academic freedom of other students as well as the instructor. ([Living our Unifying Values: The USC Student Handbook](#), page 13).

Distribution or use of notes, recordings, exams, or other intellectual property, based on university classes or lectures without the express permission of the instructor for purposes other than individual or group study. This includes but is not limited to providing materials for distribution by services publishing course materials. This restriction on unauthorized use also applies to all information, which had been distributed to students or in any way had been displayed for use in relationship to the class, whether obtained in class, via email, on the internet, or via any other media. ([Living our Unifying Values: The USC Student Handbook](#), page 13).

Course Evaluation

A final course evaluation in line with USC prescriptions will occur at the end of the last teaching session and before the final exam.

Statement on Academic Conduct and Support Systems

Academic Integrity:

The University of Southern California is a learning community committed to developing successful scholars and researchers dedicated to the pursuit of knowledge and the dissemination of ideas. Academic misconduct, which includes any act of dishonesty in the production or submission of academic work, comprises the integrity of the person who commits the act and can impugn the perceived integrity of the entire university community. It stands in opposition to the university's mission to research, educate, and contribute productively to our community and the world.

All students are expected to submit assignments that represent their own original work, and that have been prepared specifically for the course or section for which they have been submitted.

You may not submit work written by others or “recycle” work prepared for other courses without obtaining written permission from the instructor(s).

Other violations of academic integrity include, but are not limited to, cheating, plagiarism, fabrication (e.g., falsifying data), collusion, knowingly assisting others in acts of academic dishonesty, and any act that gains or is intended to gain an unfair academic advantage.

The impact of academic dishonesty is far-reaching and is considered a serious offense against the university. All incidences of academic misconduct will be reported to the Office of Academic Integrity and could result in outcomes such as failure on the assignment, failure in the course, suspension, or even expulsion from the university.

For more information about academic integrity see [the student handbook](#) or the [Office of Academic Integrity’s website](#), and university policies on [Research and Scholarship Misconduct](#).

Please ask your instructor if you are unsure what constitutes unauthorized assistance on an exam or assignment, or what information requires citation and/or attribution.

Students and Disability Accommodations:

USC welcomes students with disabilities into all of the University’s educational programs. The Office of Student Accessibility Services (OSAS) is responsible for the determination of appropriate accommodations for students who encounter disability-related barriers. Once a student has completed the OSAS process (registration, initial appointment, and submitted documentation) and accommodations are determined to be reasonable and appropriate, a Letter of Accommodation (LOA) will be available to generate for each course. The LOA must be given to each course instructor by the student and followed up with a discussion. This should be done as early in the semester as possible as accommodations are not retroactive. More information can be found at osas.usc.edu. You may contact OSAS at (213) 740-0776 or via email at osasfrontdesk@usc.edu.

Support Systems:

[Counseling and Mental Health](#) - (213) 740-9355 – 24/7 on call

Free and confidential mental health treatment for students, including short-term psychotherapy, group counseling, stress fitness workshops, and crisis intervention.

[988 Suicide and Crisis Lifeline](#) - 988 for both calls and text messages – 24/7 on call

The 988 Suicide and Crisis Lifeline (formerly known as the National Suicide Prevention Lifeline) provides free and confidential emotional support to people in suicidal crisis or emotional distress 24 hours a day, 7 days a week, across the United States. The Lifeline is comprised of a national network of over 200 local crisis centers, combining custom local care and resources with national standards and best practices. The new, shorter phone number makes it easier for people to remember and access mental health crisis services (though the previous 1 (800) 273-8255 number will continue to function indefinitely) and represents a continued commitment to those in crisis.

[Relationship and Sexual Violence Prevention Services \(RSVP\)](#) - (213) 740-9355(WELL) – 24/7 on call

Free and confidential therapy services, workshops, and training for situations related to gender- and power-based harm (including sexual assault, intimate partner violence, and stalking).

[Office for Equity, Equal Opportunity, and Title IX \(EEO-TIX\)](#) - (213) 740-5086

Information about how to get help or help someone affected by harassment or discrimination, rights of protected classes, reporting options, and additional resources for students, faculty, staff, visitors, and applicants.

[Reporting Incidents of Bias or Harassment](#) - (213) 740-5086 or (213) 821-8298

Avenue to report incidents of bias, hate crimes, and microaggressions to the Office for Equity, Equal Opportunity, and Title for appropriate investigation, supportive measures, and response.

[The Office of Student Accessibility Services \(OSAS\)](#) - (213) 740-0776

OSAS ensures equal access for students with disabilities through providing academic accommodations and auxiliary aids in accordance with federal laws and university policy.

[USC Campus Support and Intervention](#) - (213) 740-0411

Assists students and families in resolving complex personal, financial, and academic issues adversely affecting their success as a student.

[Diversity, Equity and Inclusion](#) - (213) 740-2101

Information on events, programs and training, the Provost's Diversity and Inclusion Council, Diversity Liaisons for each academic school, chronology, participation, and various resources for students.

[USC Emergency](#) - UPC: (213) 740-4321, HSC: (323) 442-1000 – 24/7 on call

Emergency assistance and avenue to report a crime. Latest updates regarding safety, including ways in which instruction will be continued if an officially declared emergency makes travel to campus infeasible.

[USC Department of Public Safety](#) - UPC: (213) 740-6000, HSC: (323) 442-1200 – 24/7 on call

Non-emergency assistance or information.

[Office of the Ombuds](#) - (213) 821-9556 (UPC) / (323-442-0382 (HSC)

A safe and confidential place to share your USC-related issues with a University Ombuds who will work with you to explore options or paths to manage your concern.

[Occupational Therapy Faculty Practice](#) - (323) 442-2850 or otfp@med.usc.edu

Confidential Lifestyle Redesign services for USC students to support health promoting habits and routines that enhance quality of life and academic performance.