PHY 317 - Fall 2020 - Stellar and Interstellar Astrophysics

Course Description

Welcome! This course offers the motivated student an opportunity to learn about one of the most fascinating topics in astronomy and astrophysics: **the exploration of star birth, evolution and death**. Intertwined with star birth is the formation of protoplanetary disks. From them, planets eventually form. The discovery of hundreds of planets outside our solar system by the KEPLER space telescope and the detection of extrasolar planetary atmospheres have ignited a quest to study Earth-like planets and the conditions under which they form.

This course goes beyond the level of a descriptive astronomy course or book; it shows how fundamental laws of physics are applied to describe and understand phenomena occurring in and around stars. ***This is one of the few cases in the undergraduate curriculum where one can see how simple physical laws are used to explain actual natural phenomena.*** This course is designed for students who have learned physics before, preferably at the college level or at an equivalent advanced high-school level, and have acquired some proficiency with calculus. Each lecture is designed to take the student one step closer to understand how stars work and change. The reference point will be the Timetable (available in Blackboard); it has up-to-date information on reading assignments.
During this course, students will be able to dwell into specific aspects of the course material by working on a ***research project***. The results of this mini research will be presented at the end of the semester.

Pre-requisites: The course has the following co-requisites: general physics course with calculus (PHY211/PHY212 or equivalent) and MAT285 or MAT 295. Having taken or concurrently taking a course in modern physics is a plus. Make sure you register for the appropriate courses.

Important note: the course uses elements of the "*flipped classroom*": students complete pre-lecture reading assignments; in class, the instructor goes over selected parts of the pre-lecture assignments, and then students work, in

	class, on exercises, problems, and quizzes related to the pre-lecture material.
Course Goals	* To introduce one of the most important fields of astrophysics: how stars are born, evolve and die; * To give a flavor of 21st century research in one of the most exciting fields of physics; * To learn how to use basic physics laws to describe complex phenomena, such as the ones occurring in and around stars; * To build skills in problem solving, modeling and doing research.
Textbook	There is no required textbook. Mike Guidry: " Stars and Stellar Processes", Cambridge University Press, 2019, available at the SU Bookstore. The textbook has much more material than it is possible to teach in a semester. Therefore, we will select chapters and sections to study. When necessary, notes will be distributed through Blackboard.syr.edu Useful books that have material very closely linked to the course: a) D.A Ostlie & B.W. Carroll: *Introduction to Modern Stellar Astrophysics* Addison-Wesley, on reserve in the SU Library b) A.C.Phillips: *The Physics of Stars*, John Wiley and Sons, on reserve in the SU Library c) Dina Prialnik: *An Introduction to the Theory of Stellar Structure and Evolution*, Cambridge University Press, available in the SU Library d) Mike Guidry: " Stars and Stellar Processes", Cambridge University Press, 2019. Available on Amazon. The suggested books are also available as "used" at Amazon.com
Meeting Times and Location	Lectures: Mondays and Wednesdays, 2:15pm -3:35pm, Rm. 208, Physics Bldg.
Attendance Policy	**Attendance at lectures is strongly advised** because the course is built around active participation and in-class work (15% of the grade). **Students who miss classes have the responsibility to find out what was missed**. Attendance at **ALL** final presentations is mandatory.

	Reading and homework assignments, and other important communications, are given in class and on Blackboard. However, sometimes it is not possible to post such announcements on the Web in a timely fashion.
Instructor	Lecturer: Prof. Gianfranco Vidali Office: Rm. 221 Physics Bldg. Contact information: 443-9115, gvidali@syr.edu Office hours: Thursday 2 pm – 3 pm, and by appointment. You are welcome to drop in at other times too. If I am not in my office, I might be in my lab, B215, sub-basement. Prof. Vidali's research interests: astrophysics, specifically the study of physical and chemical processes in the interstellar medium. See the Website at http://astro.syr.edu
Coursework	The course is at the 300 level. This doesn't require that you be a junior in order to take it, but rather it is understood that you should possess a certain level of ***self-direction and discipline*** in planning and carrying out your work. You will also be asked to learn a lot of new material and to apply it right away. This requires a certain flair for being able to go to the heart of a problem and grasp it in its main attributes. This way of working will come handy later on and should be considered an important tool in your bag of tricks when you graduate, whatever job you'll take. There will be a fair amount of coursework, both done in class and on your own. As the course is conceived, the basic tools are given first, and to progress in the course you need to have mastered these tools; thus, it is imperative that you don't fall behind, *especially in the first month*. If you think you are having difficulty understanding the course material or completing the assignments, see the instructor at once! **Coursework consists in**: • pre-lecture readings • graded work in class (quizzes, midterm exams, etc.) • studying and doing the assigned weekly homework sets, and • working on a final project. This course uses Blackboard Information Technology. Written and reading assignments and reading material will be posted on Blackboard.

Homework Assignments	Homework assignments, as underscored by the weight given to them in the grading, perform a very important function: they test what you just learned, they develop or build up thinking skills in you, and they make you revisit material, learned in class or on books, in a new light. You are encouraged to *consult* on homework assignments with other students of this course. However, **each student is required to present his/her own work.** **IMPORTANT: whether in homework assignments or in the final project, every bit of material that has been taken verbatim by whatever source (books, journals, Internet, experts, etc.) should be placed in quotes and its source acknowledged.** Homework assignments will be given approximately once a week; you are expected to turn them in within one week after the day they were assigned. Turn in the assignment in class only. No late homework assignments will be accepted. Your completed homework assignment will be graded in the following way. One or more problems of the given set will be chosen to be graded. Grading will be based on: a) Understanding of the physics behind the problem; b) Setting up the method of solution; c) Carrying out the calculations; d) Doing an honest effort in tackling the problem even if unsuccessful. The grade will represent an overall assessment of how you have done on the assignment. It is important that you attempt to work on all problems, even if unsuccessful. Partial credit is given. Answers to selected problems will be distributed or discussed in class; furthermore, if you would like to have detailed information on how parts of the assignments are graded, or want to have a certain solution clarified, you should see the instructor.
Exams	Exams are designed to verify the level of proficiency in topics of the course. There are three exams during the semester; the emphasis of the exams is on material you have not been previously tested on. **There are no make-up exams.**
Project	The research project consists of an investigation on a course-related topic chosen by students and approved by the instructor. Thus, the project should be the showcase of what students can do when they learn about something that they are excited about. In the best cases, the project goes beyond an exercise in understanding the chosen topic; through it there

	will have an opportunity to show some creativity. The student will give a presentation using a poster. The student is expected to answer questions by the instructor and other students on the material presented. At that time he/she will hand in a project report of about 5-7 pages in length. The report will have an abstract, an introduction, the elaboration of the topic chosen and a bibliography. Concerning ideas for projects, one might want to pursue aspects of a topic/problem that have not been talked about in class. Suggestions and guidelines will be given later. **Note**. The selection of the specific project must be approved by the instructor by a deadline (typically mid-October) to be set later in the semester
Honesty	Please read this carefully. Homework assignments: You may consult with other fellow students in order to discuss solution strategies for the assigned problems. But eventually you must work out the problems yourself; what you turn in must be your own product. Work by others, whether it is taken verbatim or paraphrased, must be clearly identified and attributed. Turning in an assignment copied from somebody else's solutions or completed by somebody else is considered **cheating.** Exams: It is a violation of the academic code to seek or give assistance during the exams. The instructor is the only person you can communicate with during the tests. Please do not make any changes or marks to the graded exams, if you want to preserve a right to appeal grading mistakes. The general Syracuse University guidelines will be followed in case of violations.
Grading	The final grade is obtained as follows: • **homework assignments** (15%), • **three exams** (60% total; of the three, the exam with the highest score gets 30%, then the second best 20%, and the third 10%), • **final projec**t (15%). • **in-class work** (solving problems, quizzes, etc.) **and active participation** (10%). Please note that there is **no final exam**. There are **no make-up exams**. A numerical score will be given for each piece of evaluated material. The final letter grade will reflect: the amount of

	work you did, the proficiency you attained in certain tasks, and the mastery of the subject matter. **There will be no curving of the final grade:** thus, it is possible, as frequently happens in upper division undergraduate and graduate courses, that the majority of the class receives a high grade (such as A's and B's). The grade break-up in this course is typically as follows: A:90-100; A-:85-90; B+:80-85; B:75-80; B-:70-75; C+:65-70; C:60-65; C-:55-60; D: 49-55; F:<49.
Getting Help	The pace of the course is pretty quick. It's important that you don't fall behind. Talk to the instructor! He is readily available outside office hours. In addition, there are the: Physics Clinic: The Physics Clinic is located in Rm.112South of the Physics Building. Hours are posted on the door (and at http://phy.syr.edu/undergraduate/physics_clinic.html). The clinic is staffed by graduate Teaching Assistants who can help you with this course material. Math Clinic: This course uses mathematics, including calculus. The Mathematics Department runs the Math Clinic, Rm.102 Carnegie Bldg.
Syracuse University Policies	Students should review the University's policies regarding: Diversity and Disability: https://www.syracuse.edu/life/accessibilitydiversity/; the Religious Observances Notification and Policy**:** http://supolicies.syr.edu/studs/religious_observance.htm; and Orange SUccess: http://orangesuccess.syr.edu/getting-started-2/.
Disability-related Accommodations	If you believe that you need accommodations for a disability, please contact the Office of Disability Services (ODS), http://disabilityservices.syr.edu, located in Room 309 of 804 University Avenue, or call (315) 443-4498, TDD: (315) 443-1371 for an appointment to discuss your needs and the process for requesting accommodations. ODS is responsible for coordinating disability-related accommodations and will issue students with documented Disabilities Accommodation Authorization Letters, as appropriate. Since accommodations may require early planning and generally are not provided retroactively, please contact ODS as soon as possible.
Diversity and Disability	Syracuse University values diversity and inclusion; we are committed to a climate of mutual respect and full participation. My goal is to create learning environments that

	are useable, equitable, inclusive and welcoming. If there are aspects of the instruction or design of this course that result in barriers to your inclusion or accurate assessment or achievement, I invite any student to meet with me to discuss additional strategies beyond accommodations that may be helpful to your success.
Academic Integrity	Syracuse University's Academic Integrity Policy reflects the high value that we, as a university community, place on honesty in academic work. The policy defines our expectations for academic honesty and holds students accountable for the integrity of all work they submit. Students should understand that it is their responsibility to learn about course-specific expectations, as well as about university-wide academic integrity expectations. The policy governs appropriate citation and use of sources, the integrity of work submitted in exams and assignments, and the veracity of signatures on attendance sheets and other verification of participation in class activities. The policy also prohibits students from submitting the same work in more than one class without receiving written authorization in advance from both instructors. Under the policy, students found in violation are subject to grade sanctions determined by the course instructor and non-grade sanctions determined by the School or College where the course is offered as described in the Violation and Sanction Classification Rubric. SU students are required to read an online summary of the University's academic integrity expectations and provide an electronic signature agreeing to abide by them twice a year during pre-term check-in on MySlice. For more information about the policy, see http://academicintegrity.syr.edu.
Religious Observance	SU religious observances notification and policy, found at http://hendricks.syr.edu/spiritual-life/index.html, recognizes the diversity of faiths represented among the campus community and protects the rights of students, faculty, and staff to observe religious holidays according to their tradition. Under the policy, students are provided an opportunity to make up any examination, study, or work requirements that may be missed due to a religious observance provided they notify their instructors before the end of the second week of classes for regular session classes and by the submission deadline for flexibly formatted classes.

	For fall and spring semesters, an online notification process is available for students in My Slice/StudentServices /Enrollment /MyReligiousObservances /Add a Notification. Instructors may access a list of their students who have submitted a notification in My Slice Faculty Center.
Absence Policy	**There will be no make-up exams.**

List of Topics - not in the order of presentation; not every topic is covered with the same depth. This list is subject to change. (See the Timetable in Blackboard for details)

Topic	Detailed list
Introductory material (to be given throughout the course as required)	**Gravity and related laws; elements of statistical physics/thermodynamics and quantum mechanics: the ideal gas, density of states, the chemical potential, quantization of matter and radiation, black-body radiation, Fermi-Dirac and Bose-Einstein statistics; the Bohr's atom, the degenerate Fermi gas, the Maxwell-Boltzmann distribution, relativistic gas, pressure of an ideal gas, electrons in stars, the photon gas, radiation pressure, the Saha's equation**
Phenomenology	**Magnitudes, spectral characteristics and classification of stars**
Heat transfer in stars	**Radiative transfer, source of opacity, stellar atmospheres**
Stellar interiors	**Hydrostatic equilibrium; the virial theorem; thermal equilibrium**
Energy sources in stars	**Thermonuclear fusion in stars**
Equilibrium stellar configurations	**The stellar structure equations; main sequence**
Stability of stars	**Thermal stability; dynamical stability; pulsations**
The evolution of stars	**From protostars to main sequence; stars on the main sequence; post main sequence evolution for low mass and high mass stars**
The interstellar medium	**Composition; characteristics of gas and dust; role of the interstellar medium in star formation**
Off main sequence	**Red giants, asymptotic giant branch; planetary nebulae; end-points of stellar evolution; white dwarfs; supernovae; neutron stars - pulsars; black holes**