



## COURSE OUTLINE

### 1. **Course:** ASPH 509, High Energy Astrophysics and Cosmology - Winter 2022

Lecture 01 : MWF 09:00 - 09:50 in SS 010

Instructor	Email	Phone	Office	Hours
Dr. Jeroen Stil	jstil@ucalgary.ca	403 220-8015	SB 519	Wednesdays, 2pm-4pm

To account for any necessary transition to remote learning in the winter 2022 semester, courses with in-person lectures, labs, or tutorials may be shifted to remote delivery for a certain period of time. In addition, adjustments may be made to the modality and format of assessments and deadlines, as well as to other course components and/or requirements, so that all coursework tasks are in line with the necessary and evolving health precautions for all involved (students and staff).

#### **In Person Delivery Details:**

This is an in-person course. Lecture recordings will be made available on D2L if technology permits. There will be no for-credit activities during the lectures. Attendance of lectures in-person or live through Zoom is recommended but not required. There are no midterm exams in this course. The term project (see Section 12 of this course outline) serves as a significant and personalized assessment of student's understanding of high-energy astrophysics. The final exam will include topics from the set sections of the textbook, lectures and the assignments. If this course is required to go on-line, office hours will be scheduled through Zoom **at a different time** (to be announced if the need arises).

#### **Re-Entry Protocol for Labs and Classrooms:**

To limit the spread of COVID-19 on campus, the University of Calgary has implemented safety measures to ensure the campus is a safe and welcoming space for students, faculty and staff. The most current safety information for campus can be found [here](#).

#### **Course Site:**

D2L: ASPH 509 L01-(Winter 2022)-High Energy Astrophysics and Cosmology

**Note:** Students must use their U of C account for all course correspondence.

#### **Equity Diversity & Inclusion:**

The University of Calgary is committed to creating an equitable, diverse and inclusive campus, and condemns harm and discrimination of any form. We value all persons regardless of their race, gender, ethnicity, age, LGBTQIA2S+ identity and expression, disability, religion, spirituality, and socioeconomic status. The Faculty of Science strives to extend these values in every aspect of our courses, research, and teachings to better promote academic excellence and foster belonging for all.

The Physics and Astronomy EDI Committee acknowledges there are persistent barriers that prevent such accessibility and hinder our progress towards EDI. Our representatives (faculty, postdocs, graduate and undergraduate students) are committed to addressing any concerns and work towards proactive solutions that enact necessary change within the department. To submit anonymous questions, comments or concerns regarding EDI related issues, please reach out to our Acting Associate Head EDI, Jo-Anne Brown ([jocat@ucalgary.ca](mailto:jocat@ucalgary.ca))

### 2. **Requisites:**

See section [3.5.C](#) in the Faculty of Science section of the online Calendar.

#### **Prerequisite(s):**

Astrophysics 401 and Physics 343.

### 3. **Grading:**

The University policy on grading and related matters is described in [F.1](#) and [F.2](#) of the online University Calendar.

In determining the overall grade in the course the following weights will be used:

Course Component	Weight	Due Date (duration for exams)	Modality for exams	Location for exams
Assignments(4) <sup>1</sup>	20%	Ongoing		
Term Project Introductory Report <sup>2</sup>	5%	Feb 06 2022		
Term Project Interim Report <sup>3</sup>	15%	Mar 06 2022		
Term Project Final Report <sup>4</sup>	25%	Apr 03 2022		
Registrar Scheduled Final Exam	35%	Will be available when the final exam schedule is released by the Registrar	in person	Will be available when the final exam schedule is released by the Registrar

<sup>1</sup> Tentatively due January 26, February 16, March 16 and March 30 at 23:59 Calgary time.

<sup>2</sup> See Section 12 of this Course Outline for description

<sup>3</sup> See Section 12 of this Course Outline for description

<sup>4</sup> See Section 12 of the Course Outline for description

Each piece of work (reports, assignments, quizzes, midterm exam(s) or final examination) submitted by the student will be assigned a grade. The student's grade for each component listed above will be combined with the indicated weights to produce an overall percentage for the course, which will be used to determine the course letter grade.

The conversion between a percentage grade and letter grade is as follows.

	A+	A	A-	B+	B	B-	C+	C	C-	D+	D
<b>Minimum % Required</b>	93 %	85 %	80 %	75%	70%	65 %	60 %	55%	50%	45 %	40 %

The course percentage grade is calculated as the weighted mean of the course components. This percentage grade will then be converted into a letter grade by application of the conversion table.

This course will have a Registrar Scheduled Final exam that will be delivered in-person and on campus. [The Final Examination Schedule](#) will be published by the Registrar's Office approximately one month after the start of the term. The final exam for this course will be designed to be completed within 2 hours.

Missing course components will receive a zero grade. Those who start early may benefit from guidance by the instructor and the TA for the term project or the assignments. Those who leave work until the last moment must realize that they must work independently and that they will be competing with others for the time that the instructor and the TA are available.

Moving weight from the term project to other course components will not be allowed. Requests to move weight from a component of the term project to another component of the term project will be denied, except in rare circumstances at the discretion of the instructor, with the possibility of additional requirements for the component that receives more weight. Students can start their term project early, meaning that last-minute rush requests will not normally be granted.

Grading of the term project will be based on the presence of required components, astrophysical insights, quality of the literature research, and formatting requirements for text and references (see Section 12 of this course outline). Grading will take into account that some topics have a larger volume of literature than other topics. Failure to follow instructions on requirements for the term project may lead to a significant reduction and possibly a failing grade. Once a grade has been assigned, there is no option for make-up work to improve that grade. The weights of the term project components are designed to allow students to benefit from feedback to improve subsequent reports. Students may elect to use Latex or Word to format their report, but Latex is recommended. See the section on Writing Quality for comments on grammar etc.

The University of Calgary offers a [flexible grade option](#), Credit Granted (CG) to support student's breadth of learning and student wellness. Faculty units may have additional requirements or restrictions for the use of the CG grade at the faculty, degree or program level. To see the full list of Faculty of Science courses where CG is not eligible, please visit the following website: <https://science.ucalgary.ca/current-students/undergraduate/program-advising/flexible-grading-option-cg-grade>

#### 4. Missed Components Of Term Work:

The university has suspended the requirement for students to provide evidence for absences. Please do not attend medical clinics for medical notes or Commissioners for Oaths for statutory declarations.

In the event that a student legitimately fails to submit any online assessment on time (e.g. due to illness etc...), please contact the course coordinator, or the course instructor if this course does not have a coordinator to arrange for a re-adjustment of a submission date. Absences not reported within 48 hours will not be accommodated. If an excused absence is approved, one possible arrangement is that the percentage weight of the legitimately missed assignment could also be pro-rated among the components of the course. This option is at the discretion of the coordinator and may not be a viable option based on the design of this course.

Missed components of course work receive a zero grade by default. Requests for accommodation must be made promptly. Specifically, late requests for accommodation for components of the term project will be denied. Concerns about marking of term work must be made promptly after the mark has been posted.

#### 5. **Scheduled Out-of-Class Activities:**

There are no scheduled out of class activities for this course.

#### 6. **Course Materials:**

Required Textbook(s):

Stephan Roswog and Marcus Brueggen, *Introduction to High-Energy Astrophysics*: Cambridge.

Hand-written lecture notes will be scanned and posted on D2L. The course notes alone will not be sufficient to be successful in ASPH 509. Students are expected to study related sections of the textbook along with the lectures. Live (and any on-line) lecture sessions will be streamed through Zoom and recorded as technology permits. The recordings will be posted on D2L. Office hours will not be recorded.

In order to successfully engage in their learning experiences at the University of Calgary, students taking online, remote and blended courses are required to have reliable access to the following technology:

- A computer with a supported operating system, as well as the latest security, and malware updates;
- A current and updated web browser;
- Webcam/Camera (built-in or external);
- Microphone and speaker (built-in or external), or headset with microphone;
- Current antivirus and/or firewall software enabled;
- Stable internet connection.

For more information please refer to the UofC [ELearning](#) online website.

#### 7. **Examination Policy:**

The final exam is closed-book. The exam may include among others, derivations, calculations, or interpretation of observational data or simulations.

Students should also read the Calendar, [Section G](#), on Examinations.

#### 8. **Approved Mandatory And Optional Course Supplemental Fees:**

There are no mandatory or optional course supplemental fees for this course.

#### 9. **Writing Across The Curriculum Statement:**

For all components of the course, in any written work, the quality of the student's writing (language, spelling, grammar, presentation etc.) can be a factor in the evaluation of the work. See also Section [E.2](#) of the University Calendar.

Students will write three reports as part of a term project. The text must be in English and present a logical sequence of facts and arguments with references inserted according to the prescribed format (see Section 13 of this course outline). Minor typos and grammatical errors will not affect the grade, but shortcomings that affect the content or legibility of the report will be included in the marking.

#### 10. **Human Studies Statement:**

Students will not participate as subjects or researchers in human studies.

See also [Section E.5](#) of the University Calendar.

#### 11. **Reappraisal Of Grades:**

A student wishing a reappraisal, should first attempt to review the graded work with the Course coordinator/instructor or department offering the course. Students with sufficient academic grounds may request a reappraisal. Non-academic grounds are not relevant for grade reappraisals. Students should be aware that the grade being reappraised may be raised, lowered or remain the same. See [Section I.3](#) of the University Calendar.

- a. **Term Work:** The student should present their rationale as effectively and as fully as possible to the Course coordinator/instructor within **ten business days** of either being notified about the mark, or of the item's return to the class. If the student is not satisfied with the outcome, the student shall submit the Reappraisal of Graded Term work form to the department in which the course is offered within 2 business days of receiving the decision from the instructor. The Department will arrange for a reappraisal of the work within the next ten business days. The reappraisal will only be considered if the student provides a detailed rationale that outlines where and for what reason an error is suspected. See sections [I.1](#) and [I.2](#) of the University Calendar
- b. **Final Exam:** The student shall submit the request to Enrolment Services. See [Section I.3](#) of the University Calendar.

Inquiries about the marking of the introductory and interim report must be made promptly after posting of the grades. These cannot be addressed at the end of the term.

## 12. Other Important Information For Students:

- a. **Mental Health** The University of Calgary recognizes the pivotal role that student mental health plays in physical health, social connectedness and academic success, and aspires to create a caring and supportive campus community where individuals can freely talk about mental health and receive supports when needed. We encourage you to explore the mental health resources available throughout the university community, such as counselling, self-help resources, peer support or skills-building available through the SU Wellness Centre (Room 370, MacEwan Student Centre, [Mental Health Services Website](#)) and the Campus Mental Health Strategy website ([Mental Health](#)).
- b. **SU Wellness Services:** For more information, see [www.ucalgary.ca/wellnesscentre](http://www.ucalgary.ca/wellnesscentre) or call [403-210-9355](tel:403-210-9355).
- c. **Sexual Violence:** The Sexual Violence Support Advocate, Carla Bertsch, can provide confidential support and information regarding sexual violence to all members of the university community. Carla can be reached by email ([syva@ucalgary.ca](mailto:syva@ucalgary.ca)) or phone at [403-220-2208](tel:403-220-2208). The complete University of Calgary policy on sexual violence can be viewed at (<https://www.ucalgary.ca/legal-services/sites/default/files/teams/1/Policies-Sexual-and-Gender-Based-Violence-Policy.pdf>)
- d. **Misconduct:** Academic integrity is the foundation of the development and acquisition of knowledge and is based on values of honesty, trust, responsibility, and respect. We expect members of our community to act with integrity. Research integrity, ethics, and principles of conduct are key to academic integrity. Members of our campus community are required to abide by our institutional [Code of Conduct](#) and promote academic integrity in upholding the University of Calgary's reputation of excellence. Some examples of academic misconduct include but are not limited to: posting course material to online platforms or file sharing without the course instructor's consent; submitting or presenting work as if it were the student's own work; submitting or presenting work in one course which has also been submitted in another course without the instructor's permission; borrowing experimental values from others without the instructor's approval; falsification/fabrication of experimental values in a report. Please read the following to inform yourself more on academic integrity:

[Student Handbook on Academic Integrity](#)  
Student Academic Misconduct [Policy](#) and [Procedure](#)  
[Research Integrity Policy](#)

Additional information is available on the [Student Success Centre Academic Integrity page](#)

### e. Academic Accommodation Policy:

It is the student's responsibility to request academic accommodations according to the University policies and procedures listed below. The student accommodation policy can be found at: <https://www.ucalgary.ca/legal-services/sites/default/files/teams/1/Policies-Student-Accommodation-Policy.pdf>

Students needing an accommodation because of a disability or medical condition should communicate this need to Student Accessibility Services in accordance with the Procedure for Accommodations for Students with Disabilities: <https://www.ucalgary.ca/legal-services/sites/default/files/teams/1/Policies-Accommodation-for-Students-with-Disabilities-Procedure.pdf>.

Students needing an accommodation in relation to their coursework or to fulfil requirements for a graduate degree, based on a Protected Ground other than Disability, should communicate this need, by filling out the

[Request for Academic Accommodation Form](#) and sending it to Dr. David Feder by email [phas.ahugrd@ucalgary.ca](mailto:phas.ahugrd@ucalgary.ca) preferably 10 business days before the due date of an assessment or scheduled absence.

- f. **Freedom of Information and Privacy:** This course is conducted in accordance with the Freedom of Information and Protection of Privacy Act (FOIPP). Students should identify themselves on all written work by placing their name on the front page and their ID number on each subsequent page. For more information, see [Legal Services](#) website.
- g. **Student Union Information:** [VP Academic](#), Phone: [403-220-3911](tel:403-220-3911) Email: [suvpaca@ucalgary.ca](mailto:suvpaca@ucalgary.ca). SU Faculty Rep., Phone: [403-220-3913](tel:403-220-3913) Email: [sciencerep@su.ucalgary.ca](mailto:sciencerep@su.ucalgary.ca). [Student Ombudsman](#), Email: [ombuds@ucalgary.ca](mailto:ombuds@ucalgary.ca).
- h. **Surveys:** At the University of Calgary, feedback through the Universal Student Ratings of Instruction ([USRI](#)) survey and the Faculty of Science Teaching Feedback form provides valuable information to help with evaluating instruction, enhancing learning and teaching, and selecting courses. Your responses make a difference - please participate in these surveys.
- i. **Copyright of Course Materials:** All course materials (including those posted on the course D2L site, a course website, or used in any teaching activity such as (but not limited to) examinations, quizzes, assignments, laboratory manuals, lecture slides or lecture materials and other course notes) are protected by law. These materials are for the sole use of students registered in this course and must not be redistributed. Sharing these materials with anyone else would be a breach of the terms and conditions governing student access to D2L, as well as a violation of the copyright in these materials, and may be pursued as a case of student academic or [non-academic misconduct](#), in addition to any other remedies available at law.

## 1. If you need assistance.

Email to the instructor is strictly for issues related to the organization of the course, or to book an appointment. Questions about course material cannot be effectively answered by email. Do not send scanned notes by email. Questions about course material can be asked immediately after class, during office hours, or by appointment. If this course is required to go on-line because of pandemic restrictions, students can send questions about their term project by email.

Office hours are assumed to be in-person. The TA will be available to provide guidance about the term project and the assignments. Students are advised to allow for some delay in response to email. Unpredictable delays in response time may be caused by meetings and other obligations of the instructor or the TAs. Especially outside office hours students should not expect an immediate response. Do not wait until the last moment. Waiting for a response is not sufficient reason for an extension.

## 2. Term project

The term project is intended to provide an individual, in-depth exploration of a topic in high-energy astrophysics based on peer-reviewed scientific literature. Students will select a topic at the start of the term. Topics are chosen from a list posted on D2L in the first week of lectures (after explanation in the first lecture), on a first come, first served basis. Every student will email their chosen topic to the instructor and wait for email confirmation of their topic by the instructor. It is not allowed to share the same topic, but those working on related topics may benefit from discussions. A list of topics already taken will be maintained on D2L. Students must consult the list of chosen topics before emailing the instructor. They may indicate a second choice in case the first choice is already taken. Topics that are not on the list may be admissible, but must be approved first by the instructor. All students must register their topic by Wednesday, January 27.

For the term project, students will write three reports, following guidance on the content outlined below. The reports must significantly exceed the discussion in the textbook in academic level and in amount of detail. Reports must refer to peer reviewed scientific journals or conference proceedings for information. References to websites are not allowed, except in very special circumstances - consult with the instructor before you do this. Students are encouraged to consult the instructor or the course TA for guidance and explanation. The term project is intended as a personalized training component of this course. Students should realize that they cannot benefit from such guidance if they postpone work on the term project to the last moment. The instructor and the TA may schedule Zoom sessions with groups of students who chose a topic within the same category.

The main subject of the reports must be in the area of high-energy astrophysics. Some objects can be studied from a different perspective that is outside the scope of high-energy astrophysics. While such information can be mentioned, it must not be the main part of a report. Students risk a failing mark if this is the case. In case of doubt, consult with the instructor in an early stage. Students should also consult the instructor prior to submitting their report if they find that they cannot meet a certain requirement for the report. The instructor may then waive the requirement, or provide guidance on an alternative.

The topics offered will be grouped in the following broad categories: Supernova Remnants and the Interstellar Medium, Active Galactic Nuclei, Diffuse Matter in Galaxy Clusters, Transient Sources, Compact Binaries, High-Energy Emission from Stars, and High-Energy Processes.

### **Requirements for the three reports.**

All reports must be based mainly on information from peer-reviewed journals. The major journals in astrophysics are *The Astrophysical Journal*, *The Astronomical Journal*, *The Monthly Notices of the Royal Astronomical Society*, and *Astronomy & Astrophysics*. There are many other peer-reviewed publications, including *Nature*, *Science*, etc. Conference proceedings are admissible, but should not constitute more than about 30% of the reference list. Not admissible as reference are the course textbook, private communication from the instructor, press releases and most other web resources. It is allowed to add a URL in a footnote if it is an essential resource that cannot be referenced through a refereed paper.

For the purpose of this course, high-energy phenomena include all processes that create, absorb or scatter X-rays and gamma rays, and synchrotron radiation at any wavelength (radio to gamma rays). You may encounter legitimate processes outside these categories. When in doubt, ask the instructor.

### **Introductory report (due February 6, 2022)**

The introductory report will be 1 page of text, single-column double spaced 12pt font plus 1 page for required figures plus 1 page for references. References must be cited in the text and formatted using the prescribed format of *The Astrophysical Journal* (<https://iopscience.iop.org/journal/0004-637X>). If the text is significantly less than 1 page, or significantly longer, the mark may be reduced.

If the topic is an object, the report must discuss the distance to the object, and its luminosity and (physical) size in each of the following wavelength ranges: radio waves, UV/Optical/Infrared (UVOIR), X-ray, and gamma ray. For X-ray and gamma ray the report must state the emission mechanisms that generate the X-rays and gamma rays, and state whether these are spectral line, continuum, or both. The report must show one or more images of the object. In case of compact variable sources, a lightcurve or discussion of the variability (periodic or not) and a spectrum can be a useful substitute for an image. All information must be described with reference to peer-reviewed journals or conference publications.

In case of an astrophysical process, the introductory report must discuss observational evidence of the process, its main observable characteristics, and a list of sources for which this process is relevant. The project must evaluate whether relativistic physics (general relativity and/or special relativity) is required to describe the physics. The figure page must show a numerical simulation, important graph, and at least one example of an observed astrophysical object that demonstrates the effect.

### **Interim report (due March 6, 2022)**

The interim report will be 2 pages of text, single-column double spaced 12pt font plus 1 page for required figures plus 1 page for references. References must be cited in the text and formatted using the prescribed format of *The Astrophysical Journal* (<https://iopscience.iop.org/journal/0004-637X>). If the report is significantly shorter or significantly longer than 2 pages of text, the mark may be reduced.

If the topic is an object, the interim report must describe the geometry of the object. If the object is variable, its variability must be described, as well as its age. The report must include a time scale for energy loss, the light crossing time, and the mean free path for particle-particle collisions. The report must discuss any sources of energy that replenish energy lost by X-ray or gamma ray emission, or include an estimate of the cooling time scale. Evidence for excellence could include the mean free path of an X-ray or gamma ray photon in the source, or other physical insights. Figures must include a diagram of the geometry of the source to accompany the text and a spectrum (related to high-energy astrophysics).

If the topic is a process, the interim report must describe the theory, in particular the relevant radiation process(es), whether the process is thermal or non-thermal, the typical energy per nucleon, a list of essential parameters that describe the physics, and a statement about opacity or a mean free path. Some processes have

interesting time scales that should be noted. Figures must include a diagram of the geometry of the process and a relevant graph from the literature that describes the process in a quantitative manner, for example a spectrum or another essential graph as appropriate.

### **Final report (due April 3, 2022)**

The final report will be 6 pages of text, single-column double spaced 12 pt font plus inserted figures (figures not included in the 6 pages) plus up to 2 additional pages for references. References must be cited in the text and formatted using the prescribed format of *The Astrophysical Journal* (<https://iopscience.iop.org/journal/0004-637X>). If the report is significantly shorter or significantly longer than 6 pages, the mark may be reduced.

The final report must synthesize a complete picture of the topic that includes observations and theory within the field of high-energy astrophysics. The final report can draw on work presented in the introductory report and the interim report, but it must contain a more extensive discussion of the literature and deeper insights than the previous reports.

## **3. Course syllabus**

We will only cover some sections of Chapters 2 and 3 as those chapters contain some material covered in prerequisite courses that are left for independent review, if necessary. In particular Sections 3.1-3.6 are deemed to be covered in ASPH 305 and ASPH 403. In the lectures we will cover the following:

Chapter 2.1: Collisions

Chapter 2.4: The equations of fluid dynamics

Chapter 2.6: Bernoulli's equation

Chapter 2.7: Shock waves

Chapter 2.8: Shock acceleration

Chapter 2.9: Fluid instabilities

Chapter 3.7: Radiation from moving charges (physics essentials and results)

Chapter 3.8: Individual radiation processes (physics essentials and results)

The following chapters cover specific high-energy phenomena. We will cover

Chapter 4: Supernovae with emphasis on supernova remnants

Chapter 5: Neutron stars, pulsars and magnetars

Chapter 5: Added topic: Fast Radio Bursts (course notes only)

Chapter 8: Active Galactic Nuclei

Chapter 6: Compact Binary systems and accretion. We will cover this topic last.

### **Course Outcomes:**

- Develop a knowledge base of theories, concepts and models with the area of high energy astrophysics.
- Collect and critically evaluate quantitative and qualitative information.
- Use well established methods to develop different approaches to problem solving.
- Formulate arguments based on concepts, information and theories and communicate them in writing and orally
- Apply knowledge in a variety of contexts, including new situations.

Electronically Approved - Jan 06 2022 16:31

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**Department Approval**

Electronically Approved - Jan 10 2022 14:53

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**Associate Dean's Approval**