



## COURSE OUTLINE

### 1. **Course:** ASPH 503, The Interstellar Medium - Winter 2023

Lecture 01 : MWF 15:00 - 15:50 in ST 128

<b>Instructor</b>	<b>Email</b>	<b>Phone</b>	<b>Office</b>	<b>Hours</b>
Dr. Jeroen Stil	jstil@ucalgary.ca	403 220-8015	SB 519	Wednesdays, 10am-11am

To account for any necessary transition to remote learning for the current 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. 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.

#### **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 503 L01-(Winter 2023)-The Interstellar Medium

**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 Associate Head EDI, Claudia Gomes da Rocha ([claudia.gomesdarocho@ucalgary.ca](mailto:claudia.gomesdarocho@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 Interim Report <sup>2</sup>	15%	Feb 28 2023		
Term Project Final Report <sup>3</sup>	30%	Apr 02 2023		
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 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, but there is an expectation that feedback on the interim report is used to improve the final report. Students may elect to use Latex or Word to format their report, but Latex (through Overleaf) 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):

Sun Kwok, *Physics and Chemistry of the Interstellar Medium*. University Science Books.

Hand-written lecture notes will be scanned and posted on D2L. The course notes alone will not be sufficient to be successful in ASPH 503. Students are expected to study related sections of the textbook along with the lectures.

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 are expected to know approximate values for density and temperature of main phases of the interstellar medium.

**The final exam will include questions and possibly a writing assignment about your term project, with emphasis on the physics discussed in ASPH 503. You will not be required to memorize exact numbers from your reports. This part of the final exam serves as an individual assessment of what you learned of the term project in relation to the subjects covered in the lectures. The relative weight of this part of the final exam will be in the range 10% to at most 20% of the final exam grade. The precise weight will be announced after approval of the final exam.**

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 two 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. Section 12 of this course outline lists requirements about structure and presentation that will be taken into account for grading.

#### 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 their [website](#) or call [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 ([svsa@ucalgary.ca](mailto:svsa@ucalgary.ca)) or phone at [403-220-2208](#). The complete University of Calgary policy on sexual violence can be viewed [here](#).
- d. **Student Ombuds Office:** A safe place for all students of the University of Calgary to discuss student related issues, interpersonal conflict, academic and non-academic concerns, and many other problems.
- e. **Student Union Information:** [SU contact](#), Email your SU Science Reps: [science1@su.ucalgary.ca](mailto:science1@su.ucalgary.ca), [science2@su.ucalgary.ca](mailto:science2@su.ucalgary.ca), [science3@su.ucalgary.ca](mailto:science3@su.ucalgary.ca),
- f. **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.

- g. **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](#)  
[Faculty of Science Academic Misconduct Process](#)  
[Research Integrity Policy](#)

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

- h. **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.
- i. **Freedom of Information and Privacy:** This course is conducted in accordance with the Freedom of Information and Protection of Privacy Act (FOIP). 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.
- j. **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.

## 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 in-depth exploration of a topic in interstellar medium research based on peer-reviewed scientific literature. Students will form teams of 2 and select a topic at the start of the term. After the first week of the term, the instructor will connect the remaining students to form teams. Concerns about participation or suspected withdrawal of a team member must be reported to the instructor without delay.

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 team will **email their chosen topic to the instructor** and wait for email confirmation of their topic by the instructor. Every topic will be assigned to at most one team 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 25.

For the term project, students will write two reports, following guidance on required content as 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. The reference list **must** follow the style of the AAS Journals as applied in The Astrophysical Journal and The Astronomical Journal, with style rules and examples provided on the website <https://journals.aas.org/references/>

Student teams are encouraged to work in LaTeX through the website <https://www.overleaf.com> and to apply automated formatting of the reference list using bibtex. Overleaf makes it possible to edit a manuscript with multiple distributed authors.

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 interstellar medium research. Some objects can be studied from a different perspective that is outside the scope of ASPH 503. 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 or an alternative.

### Requirements for the reports

Reports are submitted as a single PDF file through a designated dropbox in D2L by one member of the team.

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 such as an updated data repository that cannot be referenced through a refereed paper.

The subject matter of the reports must be the distribution, physics and chemistry of the interstellar medium (ISM) identified in the selected topic. It is not allowed to focus the discussion on a subject outside the scope of the course in which the interstellar medium is used to investigate a different astrophysical subject. For example, the distribution of dark matter can be studied by measuring the motions of interstellar gas, but it is not an appropriate topic for ASPH 503. When in doubt, ask the instructor.

### Excellence of a report is primarily demonstrated by:

- Quantitative arguments connected to physics equations.
- Detailed discussion of established knowledge substantiated by key peer-reviewed publications. Use your own words and make connections. It is almost always a bad idea to use direct quotes. If you use a brief direct quote (not more than one sentence), this must be made clear. Do not try to re-invent or paraphrase established jargon.
- Critical appraisal of recent developments substantiated by recent peer-reviewed papers.
- Sophisticated discussion beyond basic undergraduate physics and astronomy.
- Relevant additional information beyond the requirements listed in this outline.
- Citation of several papers by mutually independent research groups, not just a review paper.
- Explicit relation between information and references. For example: "Smith et al. (2003) derived a low density but Jones (2011) applied new observations to show that this was a selection effect" (good) as opposed to "The density in this object was derived by Smith et al. (2003) and Jones (2011)" (poor).
- Adherence to style and structure demonstrated in major peer-reviewed journals.

### Interim report (due February 28, 2023)

The interim report will be 3 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 AAS journals (<https://journals.aas.org/references>). If the report is significantly shorter or significantly longer than 3 pages of text, the mark may be reduced.

If the topic is an **object**, the interim report must give a general introduction to the object including but not limited to:

- Location and distance.
- Relevant phases of the interstellar medium.
- Geometry and opacity effects at various wavelengths.
- Luminosity, mass, size, etc. as appropriate.
- Significance of the object for interstellar medium research, for example the largest, the densest, the nearest, the best studied, prototype for a class of objects, deviating properties, etc.
- Key references such as discovery paper, major investigations with focus on well-established knowledge about the object.

If the topic is a **physical process**, the interim report must describe the theory, in particular the relevant radiation process(es):

- Significance for interstellar medium research.



- Key physics with equations, including a discussion of how the process is observed and a statement about thermal or non-thermal processes.
- Assumptions made in models or numerical simulations.
- Significance of opacity as a function of wavelength.
- A specific application, for example an object, or a key measurement of a property of the interstellar medium.
- Key references such as foundation of related theory, major revisions of the theory, first time observation or planned observations.

Style: Required are title, authors, reference list and a short appendix that states the contributions of each author. Do not include an abstract.

### **Final report (due April 2, 2023)**

The final report will be 8 pages of text, single-column double spaced 12 pt font plus inserted figures (figures not included in the 8 pages) plus up to 2 additional pages for references. References must be cited in the text and formatted using the prescribed format of the AAS Journals (<https://journals.aas.org/references>). If the report is significantly shorter or significantly longer than 8 pages, the mark may be reduced.

The final report must synthesize a complete picture of the topic that includes observations and theory. The final report can draw on work presented in the interim report, but it must contain a more extensive discussion of the literature and deeper insights than the previous report. Consult with the instructor if you have questions about expectations for the final report.

The final report should include subjects listed for in interim report, with improvements based on feedback, as well as

- Discussion of recent developments substantiated with recent peer-reviewed publications
- A highlight observation, simulation or model that is discussed in more detail
- Critical appraisal with outstanding questions raised in the literature
- Discussion of the object in a wider context of interstellar medium research

**The final exam will include an individual assessment related to your own term project in the form of questions or a writing assignment about your term project. The exams are closed-book.**

### **3. Course syllabus**

ASPH 503 will cover a wide range of physical processes in the interstellar medium, including

#### 1. Phases of the interstellar medium (ISM)

- Physical conditions that define phases of the ISM
- Cold molecular gas, cold neutral medium, warm neutral medium, warm ionized medium, hot ionized medium
- Volume filling factors
- Cooling function
- Radiative heating and mechanical feedback
- Chemical abundance
- Pressure in the interstellar medium
- Stable and unstable phases
- Heliopause
- Cosmic rays
- Thermal and non-thermal processes. Turbulence.

#### 2. Radiation transport

- Optical depth
- Radiative transfer equation

- Moments of intensity
- Spectral line opacity (HII regions, Lyman alpha, 2-photon emission, molecular lines)
- Local thermodynamic equilibrium (LTE)
- Partition function
- Excitation temperature, brightness temperature, kinetic temperature
- non-LTE conditions
- Continuum opacity (free-free opacity and dust opacity, modified black body)
- Ionization and bound-free opacity
- Interstellar extinction. Dust scattering, extinction curve.
- Opacity effects in the interstellar medium as a function of wavelength
- Column density
- (semi-)forbidden transitions
- Critical density

### 3. Neutral atomic hydrogen

- 21-cm line transition
- self-absorption
- Galactic rotation

### 4. Magnetic fields in the interstellar medium

- Polarization (interstellar extinction, synchrotron radiation, dust emission)
- Faraday rotation
- Zeeman splitting
- Magnetic pressure, equipartition
- Distribution of the warm ionized medium

### 5. Molecular spectroscopy

- Rotational transitions
- (Ro)-vibrational transitions
- Photo-dissociation
- Molecular hydrogen (formation, spectroscopy)
- Indirect tracers of molecular hydrogen
- Bok globules, molecular cores
- Herbig-Haro objects

#### **Course Outcomes:**

- Students analyze quantitatively the radiation transfer of spectral line and continuum radiation, considering the effects of gas dynamics on the opacity
- Students will be able to discuss two physical processes of emission and two of absorption in the interstellar



medium for each of the following parts of the electromagnetic spectrum: radio, (sub)millimeter, infrared, optical, ultraviolet and X-/gamma ray

- Students will relate the processes that determine the exchange of matter and energy between stars and the different phases of the interstellar medium to the evolution of the interstellar medium
- Students will describe the physical processes that govern heating and cooling of each phase of the interstellar medium
- Students will appraise an observational technique for the detection of interstellar matter

Electronically Approved - Jan 02 2023 16:21

---

**Department Approval**