

# UCSC Computational Astrophysics Research Group Manual

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## **Abstract.**

The University of California, Santa Cruz Computational Astrophysics Research Group consists of students, postdoctoral scholars, and faculty conducting forefront astrophysics research using computationally-intensive means. Our research efforts include hydrodynamical and cosmological simulation, deep learning applied to astronomy, and analysis of large-volume data. This Research Group Manual provides an overview of our policies including our Code of Conduct, and information on resources, mentorship, and best practices. And we're a fun group of people!

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## **1 Mission Statement**

**UCSC Computational Astrophysics Research Group** is a collaboration of research scholars who leverage state of the art numerical methods to conduct forefront science.

## 2 Overview

The UCSC Computational Astrophysics Research Group (CARG) conducts research in a variety of topics related to galaxy formation and evolution. While we work primarily on theory and simulation, we also apply artificial intelligence/machine learning to astrophysics and perform analysis on large-scale datasets.

### 2.0.1 Galaxy Formation and Evolution

Galaxy and structure formation represent fundamental concepts in our cosmological models for the evolution of the universe from inflationary perturbations to the rich collection of galaxies we see today. Our research group studies the primary physical mechanisms and modalities that give rise to the observed distribution of galaxy properties. To this end, we primarily use numerical simulations and calculations in an attempt to improve the physical realism of our models.

### 2.0.2 AI/Machine Learning in Astrophysics

AI and machine learning represent some of the most exciting technologies in science, with wide applicability to astrophysical data, theory, and simulation. The Computational Astrophysics Research Group applies deep learning to analyze and model astronomical observations, understand our astrophysical simulations, and emulate difficult calculations with rapid approximations.

### 2.0.3 Astrophysical Fluids and Turbulence

Understanding the fate of the baryonic material that comprises gas and stars in and in between galaxies is a primary goal of theoretical astrophysics. These components generate the primary observable signatures of the galaxy formation process, and are therefore key for connecting our theoretical models to observational probes. Our groups uses numerical simulation to model the properties of astrophysical fluids, which are often turbulent and complex, including dense regions of the interstellar medium that give rise to star formation, the interaction between supernovae explosions and the interstellar medium, the connection between outflowing galactic-scale winds and the circumgalactic medium, and the eventual return of gas and metals to the diffuse intergalactic medium.

### 2.0.4 Numerical Simulation Methodologies

Our group pushes the boundaries of simulation methodologies used in astrophysics by exploiting computational architectures, such as NVIDIA and AMD GPUs, to perform calculations faster and with better power efficiency while maintaining physical realism and accuracy.

### 2.0.5 Testing Theory with Observation

Effective theories share close connections with observations, and theory provides guidance for conducting observing programs with a large scientific return. Our research group is heavily involved in using theory to inform observational programs with existing and upcoming facilities like Hubble Space Telescope, James Webb Space Telescope, Nancy Grace Roman Space Telescope, Large Synoptic Survey Telescope, the Atacama Large Millimeter/submillimeter Array, and many others.

## 2.1 About This Manual

This manual is intended to provide resources and clarity for members of the Computational Astrophysics Research Group. This is a living document and will be updated as needed to reflect changes in university policy, inaccuracies, typographical errors, and to better assist CARG members in their work. We reserve the right to change this document as necessary.

Note that this manual is **not intended** to override, augment, or supersede any labor agreement between the University of California and organized workers, such as that defined by the [UC Graduate Student Researchers contract](#) or the [UC Postdoctoral Scholars contract](#). We are happy to adjust this document as needed to address any issues related to this point, and please contact Brant Robertson with any such requests. In all cases, where this document and the UC contracts could possibly disagree, the UC contracts supersede this document. This manual is not intended as a legally-binding document nor should it be interpreted as providing legal advice.

### 3 Code of Conduct and Resources

#### 3.1 Code of Conduct

As members of the Computational Astrophysics Research Group, we are committed to holding to ethical standards of conduct, professionalism, and the corresponding terms of our employment. Policies around conduct are already determined by the university through our employment contract, which this document in no way supersedes, but it can help to clarify these expectations by writing them down and by referencing the detailed University policies and resources.

UC faculty are covered by the UC Faculty Code of Conduct [APM 015](#).

For postdoctoral researchers, the terms of employment are detailed in the [UC Postdoctoral Scholars contract](#) and the process for their discipline and dismissal is outlined in its [Article 5 Discipline and Dismissal](#).

For graduate student researchers, the terms of employment are detailed in the [UC Graduate Student Researchers contract](#) and the process for their discipline and dismissal is outlined in its [Article 7 Discipline and Dismissal](#).

##### 3.1.1 Professionalism

Performing forefront research requires professionalism. The Comp Astro Research Group Code of Conduct requires professional interactions and that we satisfy expectations of professionalism. These expectations are detailed in this Manual, including especially Sections 4, 5, 6, and 7. Meeting these expectations are requirements for continued Graduate Student Researcher (GSR) positions within the Comp Astro Research Group and a PhD or Senior undergraduate thesis advising agreement with Brant Robertson. Employment conditions with the university are established separately with offer letters and contracts, and the following information does not supersede those legal arrangements.

We note here a few baseline requirements:

- Attendance at work and mandatory meetings: we expect people to be present at work during scheduled work hours and mandatory group meetings. See Sections 4 and 7.
- In-person work and meetings: we expect in-person work, in-person one-on-one meetings, and in-person group meetings. See Section 4, 5, and 7 for more information.
- Prompt communication – typical email response time is 24 hours during business days, see Section 6.

##### 3.1.2 Nondiscrimination Statement

Supporting ethical research requires ensuring a safe intellectual environment where scientists can pursue their work. The UCSC Computational Research Group will actively support all scientists and does not discriminate on the basis of race, color, national origin, religion, sex, gender identity, pregnancy, disability, age, medical condition (cancer-related), ancestry, marital status, citizenship, sexual orientation, or status as a Vietnam-era veteran or special disabled veteran.

The official University of California nondiscrimination statement can be found [here](#). Portions of this statement have been adapted for ours.

##### 3.1.3 Statement on Harassment

Racial and sexual harassment will not be tolerated by any members of the CARG. Harassment can be reported to Brant or to the Department Chair. We are mandated reporters, and any harassment reported to us will be referred to the University administration.

## **3.2 Resources**

### **3.2.1 UCSC Title IX Resources**

The UCSC Office of Diversity, Equity, and Inclusion resources are available at [https://diversity.ucsc.edu/eeo-aa/eeo/speak\\_to\\_someone.html](https://diversity.ucsc.edu/eeo-aa/eeo/speak_to_someone.html).

### **3.2.2 Student Grievances**

Information on filing a complaint or grievance with the UCSC Dean of Students Office can be found at <https://ada.ucsc.edu/about/grievance.html>

### **3.2.3 Student-Related Nondiscrimination Contact**

Inquiries regarding the University's student-related nondiscrimination policies may be directed to Eric Heng, Student Affairs Immediate Office at (510) 987-0239.

### **3.2.4 Counseling & Psychological Services (CAPS)**

If you are encountering mental health challenges that impact your work, we want you to get access to resources that can help. We care about your well being, but within the Comp Astro Research Group we are not able to diagnose mental health issues or provide psychological counseling. However, UCSC does provide Counseling & Psychological Services (CAPS).

Students can either call or walk in to CAPS during business hours to schedule a first appointment, typically within 7 business days. The CAPS phone number is (831) 459-2628. When you call, you will be scheduled for a 30- to 40-minute first appointment with a CAPS counselor. During this appointment, the counselor will learn about your concerns and help you connect with resources and services. CAPS services are confidential, and most services are free. If you want more information before calling, you can visit the CAPS website:

<https://caps.ucsc.edu/>

You may also contact the CAPS Let's Talk drop-in consultation service to get brief information, advice, or feedback from a professional counselor. Let's Talk is held several times a week at various locations around campus. You can read more about Let's Talk on their website:

<https://caps.ucsc.edu/resources/lets-talk/index.html>

### **3.2.5 Disability Resource Center (DRC)**

The Comp Astro Research Group is committed to creating an academic environment that supports its diverse student body. The <https://drc.ucsc.edu/> provides resources for students with disabilities in support of their academic goals. The DRC can mandate accommodations for students, including extending the nominal time to degree. We encourage all students who may benefit from learning more about DRC services to contact the DRC by phone at 831-459-2089 or by email at [drc@ucsc.edu](mailto:drc@ucsc.edu).

Regarding accommodations for GSR workers, please see [Article 24 on Reasonable Accommodations](#) of the UC GSR contract.

## 4 Roles & Expectations

This section outlines the typical work responsibilities members of the Comp Astro Research Group. For everyone in the CARG, the typical work schedule and mode is described in Section 5. The terms of employment are provided in the university offer letters, which typically come from the Dean's hiring authority.

### 4.0.1 Faculty

Brant's primary responsibility is to enable the research of other CARG members. He must keep the lights on, find resources, edit papers, and serve on departmental and professional committees. These responsibilities are in addition to his teaching role.

He also will occasionally try to write his own papers!

### 4.0.2 Postdoctoral Scholars

Postdocs in the CARG have a primary responsibility to pursue their research projects. A postdoctoral research position is a nominal 40-hour per week in-person time commitment for a 100% FTE.

### 4.0.3 Graduate Students

Graduate students in the CARG have different responsibilities depending on whether they are on TA, GSR, or summer GSR, and their career stage.

- For students being supported on a TA, the role is entirely academic and focused on making nominal progress toward the PhD degree (including thesis research).
- For students being supported on a GSR during the academic year, the role is a combination of academic efforts making nominal progress toward the PhD and conducting directed research. The directed research portion funded by the GSR during the academic year is a nominal 20-hour per week time commitment for a 50% FTE.
- For students on summer GSR, the role is completely directed research funded by the GSR. The directed research portion funded by the GSR during the summer quarter is a nominal 40-hour per week time commitment for a 100% FTE.

When working on a paid GSR, work activities that count toward the employment are pre-approved by the supervisor. For instance, GSR work hours spent on mentoring interns or at external conferences must be pre-approved by the supervisor.

Graduate student working roles are all nominally in-person.

### 4.0.4 Undergraduate Students

Undergraduate students have the primary responsibility of satisfying their degree requirements. Their research activities should be in support of their professional goals. Students working before their Junior year should be gaining skills to prepare for more involved research in their Junior and Senior years. Juniors wanting to pursue a graduate degree should be focused on completing a well-organized research project ahead of their graduate applications. Seniors should focus on building their professional skill sets for roles in industry or preparing research skill sets for graduate school.

Performing research and training to perform research are both forms of labor and deserve compensation. This labor could be in the context of an academic course for credit (the compensation is course credit) or as part of separate independent research (compensation is pay). If Seniors are working on a thesis project, they should be enrolled in the related thesis research course. For undergraduates who want to perform research for pay, the hiring process is handled through [UCSC's HandShake system](#). Positions are typically limited to at most part-time 50% FTE and are expected to be in-person, including during summer quarter, unless otherwise arranged in advance with Brant with written confirmation.

## 5 Logistics and Work Schedule

We have provided below some information on the logistics and work schedule. As noted throughout this document, for Postdoctoral Researchers and Graduate Student Researchers, the labor contracts dictate many of these policies and we refer to the contracts to provide the details. We are providing this information in goodwill to help clarify expectations, rights, and responsibilities. Nothing here should be interpreted to supersede or replace policies covered by labor agreements.

### 5.0.1 Work Schedule and Location

To provide the clearest possible information on work schedule and location expectations, here is a list:

- Postdoctoral researchers and GSRs in the Comp Astro research group are expected to work in-person at their provided office workspace.
- Full time (100% FTE) positions are expected to work during the nominal work hours listed in [Section 5.0.2](#).
- Part time (50% FTE) positions are expected to schedule their in-person work hours during the nominal work hours listed in [Section 5.0.2](#) and notify their supervisor about their schedule.
- Work schedules should accommodate mandatory meetings.

The work schedule and mode for everyone in the group is subject to specific, pre-approved, and documented arrangements for modifications. For GSRs, time and effort commitment is covered by the [UC GSR contract Article 28](#). For Postdocs, time and effort commitment is covered by the [UC Postdoc contract Article 25](#).

When on authorized travel, the work schedule, location, and hours can vary. Travel for Postdoctoral Researchers is covered in [UC Postdoc contract Article 28](#). For GSRs, for the travel policy see [UC GSR contract Article 29](#).

Disability accommodations may affect the nominal work schedule and location.

### 5.0.2 Nominal Work Hours

Our group's nominal work hours are 9am-5pm Pacific Time. In cases where external collaboration meetings require work during the 8am hour, which is possible given collaborations with researchers in Europe, nominal work hours may be shifted to 8am-4pm Pacific Time.

### 5.0.3 Mandatory Group Meeting

As part of the nominal work schedule, members of the CARG are required to attend the Comp Astro Research Group meeting. These mandatory meetings will only be held during Nominal Work Hours ([Section 5.0.2](#)).

### 5.0.4 Personal Time Off

Both Postdoctoral researchers and GSRs have the ability to take personal time off (PTO) as listed in their contracts.

For GSRs, PTO is detailed in [Article 23 of the UC GSR contract](#), and is nominally up to 12 days per twelve-month period, and nominally requires advance approval. See the contract for details.

For Postdocs, PTO is detailed in [Article 17 of the UC Postdoc contract](#), and is nominally up to 24 days per twelve-month period, and nominally requires advance approval. See the contract for details.

### 5.0.5 Sick Leave

Postdoctoral scholars are eligible for sick leave, as listed in [UC Postdoc contract Article 23](#). They nominally receive 12 work days per twelve-month appointment, all of which are available on the first day of the appointment. See the contract for details.



#### **5.0.6 Short Term Leave**

GSRs are eligible for short-term leave, as listed in [UC GSR contract Article 17](#), including for personal illness or disability. The nominal eligibility is 2 days per quarter for a 50% appointment and pro-rated for other appointments. See the contract for details.

#### **5.0.7 Other Forms of Leave and Absences**

Please refer to the Postdoctoral Researcher or GSR contracts for other forms of possible leave.

#### **5.0.8 University Holidays and Calendar**

We observe the normal work calendar of the University of California, Santa Cruz, including its work holidays. The UCSC official calendar can be found here:

[UCSC Academic and Administrative Calendar](#)

The university holidays encoded in the GSR contract are listed in [its Article 14](#). For Postdocs, the university holidays are encoded in the [Postdoc contract Article 8](#).

## **6 Communication**

### **6.0.1 Slack**

Slack is the primary mode of communication for the CARG, through [ucsc-comp-astro.slack.com](https://ucsc-comp-astro.slack.com). Ask Brant for an invitation.

### **6.0.2 Email**

We maintain a group email list [comp-astro-group@ucsc.edu](mailto:comp-astro-group@ucsc.edu). We will use this email list for announcements. Your UCSC email will be signed up for a variety of other lists managed by the university and department.

### **6.0.3 Response Timeline**

Expectations for CARG member communications on a reasonable timescale, typically within 24 hours for email and as permitting via Slack. We do not expect communications from CARG members after business hours, over the weekend, or on holidays. If you receive communications from Brant or another CARG member outside of business hours, please assume it is because they had the opportunity to do so and not because they expect you to communicate during those times.

### **6.0.4 Websites**

Please develop and maintain a professional website. A good option is a GitHub.io site (for instance, Brant's [github.io site](#)). There is a [UCSC Computational Astrophysics Research Group website](#). We can cross-link sites as desired.

## **7 Events**

### **7.0.1 Group Meetings**

Mandatory in-person group meetings will be held, usually weekly, and will be announced a week in advance. A typical location is the CfAO Atrium interaction area, typically on Mondays at 11am or Tuesdays at 10am. We discuss current events, research activities, university happenings, etc. Group members may be asked to share their current successes and challenges, or present slides with advanced notice. The in-person group meetings are mandatory for CARG members.

### **7.0.2 Cosmo Club**

The cosmology and galaxy formation-focused weekly seminar is Cosmo Club, which is held Mondays 12:30pm - 1:30pm in ISB 102. CARG members should attend this weekly seminar and sign up to meet with speakers.

### **7.0.3 Astronomy Colloquia**

The Astronomy colloquia are a critical event for the intellectual culture of the Astronomy department, and all members of CARG should attend every week as possible. They are held on Wednesdays at 10 AM - 12PM, including pre-colloquium Tea (usually in CfAO) and the (usually in Nat Sci Annex 101).

Usually, a meeting schedule is created for the colloquium speaker each week. Please sign up to meet with every colloquium speaker as schedule permits.

The [Astronomy Colloquium Schedule](#) is available here.

### **7.0.4 Physics Colloquia**

The Physics Department Colloquia are usually scheduled from 3:45 pm-4:55 pm on Thursdays in Physical Sciences 114. They serve cookies at 3:20pm in the ISB foyer. CARG members are encourage to attend this optional event.

The [Physics Colloquium Schedule](#) is available here.

### **7.0.5 FLASH**

The weekly informal departmental seminar is the Friday Lunch Time Astrophysics Seminar, which is held Fridays 12pm - 1pm, usually in ISB 102. CARG members should attend this weekly event.

In the Spring, second year graduate students usually present their research at FLASH. It's especially important to attend FLASH during this time to support our students.

## 8 Programming Resources

The CARG deploys a wide range of computer programming, including research code, website construction, and plotting and visualization. Here we provide access to some resources for programming and outline languages, tools, and libraries that we use regularly.

### 8.1 Software Repositories

Before you get started writing code, it's essential to start by creating a software repository for yourself. We use [GitHub](#), although there are other alternatives. Get used to the idea of [creating repositories](#), documenting them using the [README.md](#) file, [branching your code](#), updating the main branch by [pull requests](#). Create [issues](#) to document bugs or feature requests.

### 8.2 Text Editors

You should pick a text editor with which to become proficient. Emacs or vi are standard (Brant unfortunately learned vi in 1999 and was stuck with it), but among the best editors now available is [Sublime Text](#). Full use does require a license, so ask about purchasing one via reimbursement.

#### 8.2.1 Documentation

The primary means of documenting your code and research can come in multiple flavors. We use all of the following

- Doxygen
- Read The Docs
- Markdown
- Readme.md

### 8.3 Computer Languages

We spend a lot of time programming, and it's important to develop both skill with programming languages and a support structure for getting help as needed. Always reach out on the Slack channel or via email.

#### 8.3.1 Compilation

We use [GNU make](#) to link and compile our code. A good example makefile is the [Cholla makefile](#). You can use this as a template.

#### 8.3.2 C/C++

The core of our high-performance computational work is performed in C/C++. Good resources include

- The standard C textbook by Kernighan & Ritchie [[1](#)].

The main C/C++ software libraries we use are

- [NVIDIA CUDA](#)
- [Message Passing Interface \(MPI\)](#)
- [GNU Science Library](#)
- [Fast Fourier Transform in the West \(FFTW\)](#)

### 8.3.3 Python

The main Python modules that we use are

- [numpy](#)
- [scipy](#)
- [matplotlib](#)
- [astropy](#)

To install Python modules, use the [pip](#) tool. Have a look at the [pip installation notes](#).

Here are variety of additional Python libraries that may prove useful:

- [Bokeh](#)
- [CuPy](#)
- [Datashader](#)
- [HoloViews](#)
- [HoloViz](#)
- [Pandas](#)
- [Panel](#)

### 8.3.4 Jupyter

Almost all of our analysis will be done in [Jupyter](#) notebooks. These will most frequently (always?) be in the form of Python 3 notebooks. Jupyter can be [pip](#) installed.

### 8.3.5 Cholla

One of our essential simulation codes is [Cholla](#) by Evan Schneider, which is available on [GitHub](#).

## **9 Using Git**

### **9.1 Useful Git Commands**

\* `git reset --hard origin/main` \* `git pull`

## **10 Engagement**

Public outreach, social media, and press engagement can all form portions of our work. You are of course welcome to pursue these activities on your own time and these will invariably mix with professional activities. Below we list some related guidelines.

### **10.0.1 Social Media**

Social media consist of an important platforms for communication and networking. When representing CARG on social media, through communicating your results, discussing conference activites, etc., please aim to be effective and professional. Ultimately, we are responsible for maintaining our own professional reputations. We do not currently maintain group social media accounts. Brant has a Twitter account, but he's been unable to access it for a few years! Other social networks include Facebook and LinkedIn.

### **10.0.2 Press Engagement**

Regarding press activity, any engagement about CARG research should be coordinated with Brant. He commits to include and center other CARG members as appropriate.

### **10.0.3 Public Outreach**

Public outreach is an important facet of our mission as scientists. Treat public outreach as professionally as your research. The CARG will share outreach resources. Please responsibly manage the relative prioritization of research and outreach.

## 11 Finances & Reimbursements

The CARG is funded primarily by NASA, the National Science Foundation, and Hubble and James Webb Space Telescope-related grants.

### 11.0.1 Accounts

For reference, here is a listing of some the CARG accounts and FOAPALS.

- NSF MRI 81428-443162
- NASA ATP 83290-443162
- JWST NIRCcam 63513-443162

For reference, here are some now-defunct FOAPALS from previous projects:

- WFIRST 83263-443162
- LACES 58437-443162

### 11.0.2 Travel Reimbursements

Always get pre-approval from Brant on travel, including conference fees, flight arrangements, hotel arrangements, etc. University policies related to travel can be found at [https://financial.ucsc.edu/Pages/Travel\\_Process.aspx](https://financial.ucsc.edu/Pages/Travel_Process.aspx). These resources supersede any of Brant's understandings of reimbursement policies.

### 11.0.3 CruzFly

Perhaps the most important form is now [CruzFly](#), which you will need to request most reimbursements. This form should be filled out by the CARG members who are requesting the reimbursement, and then provided to Brant to fill in the FOAPAL info and authorization. If you need help, ask Brant.

### 11.0.4 Direct Payments

If you need to be reimbursed for supplies, books, software, etc., the easiest way to achieve this is to purchase using a credit card and then submit a direct payment reimbursement using [CruzFly](#). All purchases need to be authorized by Brant *before they occur*. Again, we can only guarantee reimbursements for pre-approved purchases following the university guidelines.

### 11.0.5 Reappointments

The UCSC PSC Division handles reappointment requests for postdocs through the [Postdoc Reappointment Form](#). Researchers are reappointed through the [Researcher Reappointment Form](#). Reappointments require a signed [annual evaluation form](#) to be completed and submitted with the reappointment request.



## 12 Mentoring Agreements

If you would like to develop a Mentoring Agreement to clarify the professional relationship and goals related to working in the Computational Astrophysics Research Group, we are happy to develop one. We provide below an example Mentoring Agreement created by the [UCSC Center for Innovations in Teaching and Learning](#) that we can adapt to best support your collaboration in the CARG. Many of the topics are already outlined elsewhere within this Manual, but a Mentoring Agreement can helpfully augment these policies by tailoring terms to your needs.

### 12.1 Example Mentoring Agreement

This document provides an adaptable structure and set of topics to discuss when setting up a mentorship relationship. Both mentors and mentees can review their responses to these questions and work together to establish guidelines for their mentorship relationship, toward the end of supporting the mentee to succeed in their research program and to make progress toward their personal and professional goals. This document can be developed collaboratively and revisited whenever necessary.

1. Shared Goals & Vision (List the goals of this working relationship. What do you both hope to get out of working together? What skills and experience will the mentee gain through the project, and how will that learning serve their larger academic, personal, professional goals?)
  - Research project goals:
  - Mentee's personal/professional goals:
  - Mentor's personal/professional goals:
  - Shared vision of success for this project:
2. Approaches/Strategies/Steps to achieving listed goals (What do you both need to do to meet the above goals? Who is responsible for what actions?)
  - Mentor's role/tasks:
  - Mentee's role/tasks:
3. Meeting Practices (Frequency, duration, format and platform for meetings, who will schedule the meetings, etc.)
4. Meeting Preparation (What will the mentee do to prepare for meetings? What will the mentor do to prepare for meetings?)
5. Communication Etiquette (How will the mentor and mentee communicate between meetings? Establish preferred modes of contact, timeframe for responsiveness, when to contact faculty mentor v. when to contact graduate student mentor, etc.)
6. Unplanned Issues (How will the mentor and mentee address unplanned issues that come up? For example, if the mentee gets stuck while working on the project, what are some steps they can take?)
7. Confidentiality Concerns (Ensure you are on the same page in terms of keeping particular discussions in confidence. If there are topics which either of you feel are off-limits for discussion, those can be named.)

## 13 Acknowledgments

This group manual was inspired by this [tweet from @samuelmehr](#). We have also made use of some information provided by the [UCSC Center for Innovations in Teaching and Learning](#).

## References

1. Kernighan, B. W. & Ritchie, D. M. *The C programming language* (1988).