# Shubh AGRAWAL

## Physics Senior at the California Institute of Technnology

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● 1200 East California Boulevard, MSC 122, Pasadena, CA - 91125   ⓘ Citizen of India

## 🏛 RESEARCH INTERESTS

> Astronomical Instrumentation
> Superconducting Detectors

> Observational Cosmology
> Exoplanet Direct Imaging

> Statistics and Computation
> Open-Source Software

## 🎓 EDUCATION

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|---|---|
| Present<br>September 2018 | **CALIFORNIA INSTITUTE OF TECHNOLOGY, Pasadena, CA, USA** — GPA: 4.2 |

`Bachelor of Science` `Physics Major` `Astrophysics Minor` `Computer Science Minor`

Relevant Coursework:
> Classical Mechanics and Electromagnetism, Quantum Mechanics, Particle Physics, Quantum Algorithms, Quantum Hardware, Astronomy and Cosmology
> Astronomical Instrumentation Lab, Senior, Sophomore, and Freshman Physics Labs, Signal Processing
> Differential Equations, Bayesian Statistics, Physical Methods, Information and Logic, Discrete Math
> Data Structures, Decidability and Tractability, Algorithms, Systems Architecture

Activities:
> Academic Honor Code Committee, Physics Student-Faculty Committee, Undergraduate Admissions Ambassador, Undergraduate Physics Mathematics and Astronomy Committee
> Peer Advocate, Ricketts Hovse Vice President, Review Committee Chair

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| December 2021<br>October 2021 | **UNIVERSITY OF CAMBRIDGE, Cambridge, United Kingdom** |

`Natural Sciences Tripos` `Corpus Christi College`
> Caltech Cambridge Scholars Program (One Term Study Abroad Exchange Fellow)
> <u>Coursework</u>: Particle Physics, Relativity, Relativistic Astrophysics and Cosmology, Thermal and Statistical Physics

## 📖 PUBLICATIONS

**STRONG NEGATIVE ELECTROTHERMAL FEEDBACK IN THERMAL KINETIC INDUCTANCE DETECTORS** — 2021
(Peer-Reviewed) 🔗 Journal of Applied Physics   🔗 arXiv preprint

**Shubh Agrawal**, Bryan Steinbach, James J. Bock, Clifford Frez, Lorenzo Minutolo, Hien Nguyen, Roger O'Brient, Anthony Turner, Albert Wandui

Published as an Article to the *Journal of Applied Physics* on September 28, 2021.

`Observational Cosmology` `BICEP Array` `TKIDs`

**PLANET DETECTION & ANALYSIS AND INSTRUMENT CALIBRATION MODULES FOR HIGH RESOLUTION SPECTROSCOPY** — 2022
(In progress)
Shubh Agrawal

Senior Major Thesis. Defense expected in June 2022.

`Direct Imaging` `IFS` `OSIRIS` `breads`

# 🔬 Research Experience

**Present**
**June 2021** | OSIRIS Direct Imaging Group, Exoplanet Technology Laboratory, Caltech, Pasadena, CA
🐙 github.com/jruffio/breads
- ❯ Created the open-source Broad Repository for Exoplanet Analysis, Discovery, and Spectroscopy.
- ❯ Discovered and analyzed a binary stellar companion around HD 148352.
- ❯ Detected Kappa Andromedae b in J band for the first time, using Keck-OSIRIS data.
- ❯ Created modules to perform FOV-dependent wavelength and resolution calibration in data from Integral Field Spectrographs.
- ❯ Developed modules to detect and analyze companions in IFS data using MCMC and forward modelling

`Direct Imaging` `IFS` `OSIRIS` `Python` `Git` `Open-Source` `MCMC`

**August 2021**
**June 2020** | TKID Group, BICEP Keck Collaboration, Caltech Observational Cosmology, Pasadena, CA
- ❯ Demonstrated and analyzed negative electrothermal feedback in Thermal Kinetic Inductance Detectors in the high readout power regime.
- ❯ Designed configurations that speed up the detector by $\approx 16$ times, makes response linear to 0.1% in a nominal incident power range, and maintains the noise levels below design photon noise.
- ❯ Implemented methods that could use existing cryostat setups at Caltech and JPL to characterize a TKID, perform non-linear frequency sweeps, measure time constants and noise levels, and demonstrate linearity.

`TKID` `Cryostat` `Data Science` `Python` `Bash` `Jupyter` `Manuscripy Writing`

**June 2020**
**March 2020** | Undergraduate Researcher, LIGO Astrophysics Group, Caltech, Pasadena, CA
🔗 Google Colaboratory
- ❯ Developed computational tools to perform automated fitting of merger and ringdown in GW signals using decaying sinusoidals at Kerr quasi-normal mode frequencies, with aim of comparing GR waveform models.
- ❯ Completed independent reading on general relativity and gravitational wave literature, computational models like SEOBNRv4_opt, quasinormal modes of black holes, GW spectroscopy, and stochastic gravitational wave backgrounds.
- ❯ Completed and improved the LIGO GW Open Data platform to learn techniques in signal processing and GW data reduction.

`GW` `LIGO` `Data Science` `Simulation` `Signal Processing`

**March 2020**
**January 2019** | Receiver Group, BICEP Keck Collaboration, Caltech Observational Cosmology, Pasadena, CA
- ❯ Designed and constructed an assembly that achieved the angular calibration of the first receiver of the BICEP Array using far field beam characterization.
- ❯ Machined parts, integrated the assembly with cryostat and thermal test source, and designed a gearbox to achieve precision of 10 arcminutes on optical plane.
- ❯ Developed firmware for stepper motors. Implemented Python interfaces for assembly code on Arcus controllers, running grid beam maps, and executing C scripts for collecting receiver data.

`Characterization` `Angular Calibration` `Python` `C/C++` `Firmware` `Assembly` `SolidWorks` `Machining`

# 👤 Presentations and Conferences

### South California Conference for Undergraduate Research                    2019
🔗 sccur.org
Presented "Angular Calibration of the BICEP Array receivers using Far Field Beam Map Characterization"

`Observational Cosmology` `BICEP Array` `Angular Calibration`

### California Institute of technology Summer Undergraduate Research Seminar Day          2019-2021
🔗 2021    🔗 2020 (Video+Slides)    🔗 2019 (Slides)
Presented "Planet Detection & Analysis and Instrument Calibration Modules for High Resolution Spectroscopy using Integral Field Spectrographs" in 2021.
Presented "Strong Negative Electrothermal Feedback in Thermal Kinetic Inductance Detectors" in 2020.
Presented "Angular Calibration of the BICEP Array receivers using Far Field Beam Map Characterization" in 2019.

`Observational Cosmology` `BICEP Array` `Angular Calibration` `TKIDs` `Exoplanet Technology` `breads`

### Quantum Coalition Hack — 2021

🔗 quantumcoalition.io  🔗 Video

Selected from about 80 projects and invited to present a talk.
Presented "Microsoft Quantum Development: Grover's Algorithm for the Graph Edge Coloring Problem and Fast Hamiltonian Compilation".

`Quantum Algorithms` `Python` `Q#`

### Sagan Exoplanet Workshop — 2021

🔗 nexsci.caltech.edu

`Exoplanet Technology` `breads`

### Network of Young Researchers in Instrumentation for Astrophysics Workshop — 2021

🔗 nyriastronomy

Presented "Direct imaging of exoplanets at closer separations using high resolution spectroscopy"

`Exoplanet Technology` `breads`

### 239th Meeting of the American Astronomical Society — 2022 (Expected)

🔗 aas239

Will present "Detecting and analyzing exoplanets at lower separations using high resolution integral field spectroscopy"

`Exoplanet Technology`

## 🏅 Awards and Honors

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|---|---|---|
| 2021 | Rita A. and Øistein Skjellum SURF Fellow | California Institute of Technology |
| 2020 | Dr. Gary Stupian SURF Fellow | Caltech & The Aerospace Corporation |
| 2018, 2019, 2020 | Milton & Rosalind Chang Scholarship | California Institute of Technology |
| 2018 | Indian OCSC Member | International Olympiad of Astronomy and Astrophysics |
| 2016 | Gold Medal and International Rank 1 | SOF's Science Olympiad |
| 2017, 2018 | KVPY Research Fellowships | Indian Institute of Science |
| 2016, 2017 | Rank 1 and Qualifier | National Standard Exam in Physics, and Astronomy (Indian stages of IPhO and IOAA) |
| 2017 | Sakura Program Fellow | Japan Science and Technology Agency |
| 2017 | International Scholar with Distinction | Advanced Placements |
| 2016 | National Talent Search Scholar | National Council of Educational Research and Training |

## ⭐ Observation Time

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|---|---|---|
| Half 1 of 2023 | OSIRIS (Keck)$^\times$ | $\approx 6$ Half-Nights: $\approx 10$ targets in the Ophiuchus star-forming region |
| Half 1 of 2023 | OSIRIS (Keck)$^\times$ | $\approx 6$ Half-Nights: Characterization of explanatory system Kappa Andromedae b |
| Half 2 of 2022-23 | OSIRIS (Keck) | $\approx 6$ Half-Nights: $\approx 10$ targets in the Taurus star-forming region |
| Half 2 of 2022-23 | OSIRIS (Keck) | $\approx 6$ Half-Nights: Characterization of explanatory system Kappa Andromedae b |
| August 2021 | OSIRIS (Keck) | Two Half-Nights: Characterization of explanatory system Kappa Andromedae b |
| July 2021 | OSIRIS (Keck) | Three Half-Nights: Characterization of explanatory system HR 8799 bcde |
| July 2021 | KPIC/NIRC (Keck) | Four Half-Nights and Two Full-Nights: Known high-contrast targets, brown dwarves, free-floating, and young stellar binaries |
| June 2021 | OSIRIS (Keck) | Three Half-Nights: 12 targets in the Ophiuchus star-forming region |
| August 2019 | WIRC (Palomar) | Two Hours: SURF Observation Proposal: "Characterizing Cosmic Dust Emission" $\times$: contributed to proposal / co-PI |

## 💻 Teaching Experience

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|---|---|---|
| Summer 2021 | Teaching Assistant & Organizing Staff | Code/Astro: Open-Source Code Deployment Workshop for $\approx 100$ Astrophysicists |
| Spring 2021 | Teaching Assistant | Physics 3: Introductory Physics Laboratory |
| Winter 2021 | Teaching Assistant | Physics 6: Physics Laboratory |
| Fall 2020 | Grader | Physics 2: Waves, Quantum Mechanics, and Statistical Physics |
| Fall 2019 | Teaching Assistant | Computer Science 1: Introduction to Computer Programming |
| 2018-19 | Volunteer | Caltech Y Rice Program: Tutor underprivileged high-school students in STEM |
| 2018-21 | Volunteer/Mentor | Self-Guided: Tutor high-school students from India for study-abroad applications |

## 💼 Professional Experience

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|---|---|
| **Present**<br>**April 2019** | Admissions Ambassador, UNDERGRADUATE ADMISSIONS OFFICE, Caltech, Pasadena, CA<br>❯ Design and lead campus tours, student panels, and social blogs to prospective students, families, teachers, faculty, counselors, and alumni.<br>❯ Run the front desk of the Caltech Admissions office.<br>Social Outreach · Management · Communication · Writing |
| **March 2020**<br>**January 2020** | Undergraduate Assignment, DIVISION OF PHYSICS, MATHEMATICS & ASTRONOMY, Caltech, Pasadena, CA<br>❯ Designed and managed websites for courses in math and physics.<br>❯ Implemented web-scrappers to automate the archiving of old assignment data, course listings, and department webpages.<br>❯ Wrote email marketing and managed listings for the physics and math department.<br>Web Development · Python · Management · Communication · Social Outreach |
| **January 2020**<br>**October 2019** | Undergraduate Assignment, FELLOWSHIPS AND STUDY ABROAD OFFICE, Caltech, Pasadena, CA<br>❯ Facilitated communication with about 6 partner universities and created outreach materials for several exchange and fellowship programs.<br>❯ Managed the course listings, webpages, office, and library of the Caltech FASA program.<br>Management · Communication · Writing |
| **September 2017**<br>**January 2017** | Developer, INDIAN INSTITUTE OF TECHNOLOGY, DELHI, New Delhi, India<br>🔗 Abstract & Certification    🔗 Virtual Labs<br>❯ Worked on the end-user testing of the Virtual Labs project, run by the Government of India, that addresses the lack of good lab facilities and trained teachers, by allowing remote experimentation.<br>❯ Responsible for development of 3 virtual labs, each with about 10 experiments, in satellite modeling and simulation, astrophysics, instrumentation, & communications.<br>Social Outreach · Python · Web Development |

## 🌐 LANGUAGES

English ●●●●●
Hindi ●●●●●
Sanskrit ●●●○○
French ●●○○○

## </> PROGRAMMING

Python/iPython ●●●●●
C/C++ ●●●●●
Mathematica ●●●●●
Java ●●●●●
R ●●●●○
SolidWorks ●●●●○
Q# ●●●●○

Bash ●●●●●
Mathematica ●●●●●
BASIC ●●●●●
LaTeX ●●●●●
CSS/HTML ●●●○○
Android ●●○○○
x86-64 ●●●●○

## 🖥 PROJECTS

**DWAAR LUCKNOW**                                                                                            2017 - 2020
🔗 Abstract    🔗 dwaarlucknow

❯ Co-founded and ran a non-profit initiative that connects people to credible social help organizations. Connected with over *20 national non-profit*s and generated an *outreach of nearly 50,000* through our 25 partners.
❯ Created a novel system for a geographically based social petition platform, which was recognized by the **Indian Institute of Technology at Kanpur** as one of the national best student ideas at its collegiate competitions.
❯ Co-developed a website and Android application featured on radio and in newspapers.
Non-Profit · Management · Website Development · Android · Social Outreach

**LAMINA: USING MULTIPLE CORONAGRAPHS FOR HIGH CONTRAST IMAGING AND SPECTROSCOPY**                 2021
🔗 Slides
Developed the science case and co-designed an outline for a multiplexed instrument concept for high contrast imaging, as submission for the NYRIA2021 workshop hackathon.
Direct Imaging

### Quantum Hack Microsoft Challenge: Grover's Algorithm 2021

 github.com/shubhagrawal30/qchack-microsoft-challenge

Implemented quantum oracles to be used with Grover's algorithm to solve a range of classical problems. Selected from about 80 projects to be a presenter at the closing proceedings of the conference.

Quantum Algorithms

### Fast Quantum Hamiltonian Compilation 2020

 github.com/gianelgado12/cs101-Fast-Hamiltonian-Project

Analyzed the complexity of two methods of quantum hamiltonian compilation: First Order Trotter Suzuki and qDRIFT.

Quantum Algorithms

## SERVICE

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|---|---|---|
| 2019 - 2020 | Undergrad Rep | PMA Advisory Board: Advise the division administration about mentorship, career and professional development, community outreach, diversity and inclusion issues that impact the undergraduate student experience. |
| 2018 - 2022 | Club Leader | Caltech Physics Club: Organized research talks, faculty seminars, outreach, & advisory panels. |
| 2021 | Undergrad Rep | Physics Student Faculty Conference: Advise the physics option administration about academic life and curriculum review. |
| 2021 - 2022 | Chairperson | ASCIT Review Committee: Administer the elections of the campus-wide student government of Caltech. |
| 2020 - 2022 | Vice President | Ricketts House at Caltech: Responsible for the housing allotments and needs of about 70 students and physical upkeep of an undergraduate dorm at Caltech. |
| 2019 - 2020 | Campus At-large Rep | Board of Control: Adjudicate academic Honor Code violations. |
| 2019 - 2020 | Peer Advocate | Ricketts House at Caltech: Support a community of over 100 students as a resource for mental and emotional health. |
| 2018-19 | Volunteer Tutor | Caltech Y Rice Program: Tutored underprivileged high-school students in STEM. |

## REFERENCES

James J. Bock
*Professor of Physics*, Caltech/JPL
@ jjb@astro.caltech.edu
🏛 Observational Cosmology

Dimitri Mawet
*Professor of Astronomy*, Caltech/JPL
@ dmawet@astro.caltech.edu
🏛 Exoplanet Technology Group