

Vivian U

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Professional Apointments

- 2020–Present **Assistant Research Astronomer**, UC Irvine.
- 2018–2020 **Assistant Project Scientist**, UC Irvine.
- 2017–2018 **Postdoctoral Scholar**, UC Irvine.
- 2015–2017* **University of California Chancellor's Postdoctoral Fellow**, UC Riverside/Irvine.
Faculty sponsors: Gabriela Canalizo and Aaron Barth
- 2012–2015* **Thirty Meter Telescope Postdoctoral Scholar**, UC Riverside.
Faculty advisor: Bahram Mobasher

Education

- 2012 **Doctor of Philosophy, Astronomy**, University of Hawaii at Manoa, Honolulu, HI.
Ph.D. Advisors: David Sanders and Giovanni Fazio
- 2008 **Master of Science, Astronomy**, University of Hawaii at Manoa, Honolulu, HI.
- 2006 **Bachelor of Science, Astrophysics**, California Institute of Technology, Pasadena, CA.
Senior Thesis Advisor: Richard Ellis

Awards and Honors

- 2019 National Academy of Sciences Kavli Frontiers of Science Fellow
- 2015–2017 University of California Chancellor's Postdoctoral Fellowship (\$110k[†])
- 2014 Riverside Postdoctoral Association Symposium Oral Presentation Award
- 2013 *Earth, Planets and Space* Excellent Reviewer
- 2019–2012 NASA Harriett G. Jenkins Predoctoral Fellowship (\$114k)
- 2019–2012 Smithsonian Astrophysical Observatory Predoctoral Fellowship (\$20k)
- 2011 Achievement Rewards for College Scientists Fellowship (\$1k)
- 2010 University of Hawaii Graduate Division Achievement Scholarship (\$2.2k)
- 2010 NASA JPLP Mini Research Award, Jet Propulsion Laboratory (\$8k)
- 2009 Ford Foundation Diversity Fellowship – Honorable
- 2005 Monticellor Summer Fellowship, Harvard-Smithsonian Center for Astrophysics
- 2005 Rose Hills Foundation Scholarship, Caltech
- 2004–2005 L.C. & L.P. Smith Hampton Memorial Scholarship, Caltech
- 2004 Summer Undergraduate Research Fellowship, Jet Propulsion Laboratory

*Includes maternity leaves in 2013 and 2016

- 2003–2004 Edwin Hubble Scholarship, Caltech
- 2003–2004 Mayr Scholarship, Caltech
- 2003 Summer Undergraduate Research Fellowship, Caltech

Telescope and Research Grants

- 2020–2022 **NASA**, *Astrophysics Data Analysis Program*, PI (\$280k).
“Hunting for Light in the Dark: A Multiwavelength Guide to Obscured Supermassive Black Holes in Nearby Galaxy Mergers”
- 2020 **North American ALMA Science Center**, *Conference and Workshop Grant*, PI (\$7.7k).
“Extreme Galactic Nuclear Activity — Ultraluminous Starbursts and AGN”
- 2018 **Hubble Space Telescope**, *Mid-Cycle 25*, GO-15472, Co-I (PI: Evans).
“Star Cluster Formation and Evolution in Luminous Galaxy Mergers: A Joint JWST-HST Investigation”
- 2017 **James Webb Space Telescope**, *Cycle 1 ERS*, 1328, Co-I (PI: Armus).
“A JWST Study of the Starburst-AGN Connection in Merging LIRGs”
- 2014–2017 **National Science Foundation**, *Astronomy and Astrophysics Research Grant*, 1412851, Co-I (PI: Max).
“Outflows and AGN in the Nuclei of Merging Galaxies, Viewed with Laser Guide Star Adaptive Optics”
- 2015 **Hubble Space Telescope**, *Cycle 23*, AR-14303, Co-I (PI: Mobasher).
“Multi-Waveband Photometric Catalogs for the Hubble Frontier Field Clusters and their Parallel Fields”
- 2015 **Chandra X-ray Observatory**, *Cycle 17*, GO-17700440, Co-I (PI: Veilleux).
“Elliptical Galaxy in the Making: The Black Hole Activity, Galaxy-Scale Outflow, and Metal-Rich Halo of Mrk 273”
- 2013 **AAS International Travel Grant**, FIRSED2013, (\$1.1k).
- 2010 **Sigma Xi Grants-in-Aid of Research**, G20101015154321, PI (\$4.5k).
“Kinematics and Energetics in Luminous Infrared Galaxies”
- 2009 **AAS/IAU Travel Grant**, IAU General Assembly.
- 2008 **IAU Travel Grant**, 10th Asian-Pacific Regional IAU Meeting.

Publications (H-index: 21; total citations: 1,617 from ADS)

Refereed Publications (top 3 authorship) and Press Releases

- 40. **U, V.** et al. “The Lick AGN Monitoring Project 2016: Velocity-Resolved $H\beta$ Lags in Luminous Seyfert Galaxies.” 2020, to be submitted; advanced draft available upon request
- 39. **U, V.** et al. “Keck OSIRIS AO LIRG Analysis (KOALA): Feedback in the Nuclei of Luminous Infrared Galaxies.” 2019, ApJ, 871, 166

[†]Also provides five years of salary support for faculty appointment on UC Campus

38. Iwasawa, K.; U, V. et al. "Testing a Double AGN Hypothesis for Mrk 273." 2018, A&A, 611, 71
37. Davies, R.; Medling, A.; U, V. et al. "Reconstructing merger timelines using star cluster age distributions: the case of MCG+08-11-002." 2016, MNRAS, 458, 158
36. U, V. et al. "A Correlation Between Ly α Spectral Line Profile and Rest-Frame UV Morphology." 2015, ApJ, 815, 57
35. Medling, A.; U, V. et al. "Following Black Hole Scaling Relations Through Gas-Rich Mergers." 2015, ApJ, 803, 61
34. Medling, A.; U, V. et al. "Shocked gas in IRAS F17207-0014: ISM collisions and outflows." 2015, MNRAS, 448, 2301
33. Medling, A.; U, V. et al. "Stellar and Gaseous Nuclear Disks Observed in Nearby (U)LIRGs." 2014, ApJ, 784, 70
32. U, V. et al. "The Inner Kiloparsec of Mrk 273 with Keck Adaptive Optics." 2013, ApJ, 775, 115
Press coverage: "When do Black Holes Become Active? The Case of the Strangely-Shaped Galaxy Mrk 273." 2013, Universe Today, <http://www.universetoday.com/104255/when-do-black-holes-become-active-the-case-of-the-strangely-shaped-galaxy-mrk-273/>
31. U, V. et al. "Spectral Energy Distribution of Local Luminous and Ultraluminous Infrared Galaxies." 2012, ApJS, 203, 9
30. U, V. et al. "Distance Determination to M33 with FGLR." 2009, ApJ, 704, 1120
29. Conselice, C. J.; Bundy, K.; U, V. et al. "The faint and extremely red K-band selected galaxy population in the DEEP2/Palomar fields." 2008, MNRAS, 383, 1366

Other Refereed Publications

28. Kool, E. et al. "AT 2017gbl: a dust obscured TDE candidate in a luminous infrared galaxy", 2020, MNRAS, accepted, arXiv:2006.01518
27. Treister, E. et al. "The Molecular Gas in the NGC 6240 Merging Galaxy System at the Highest Spatial Resolution." 2020, ApJ, 890, 149
26. Larson, K. L. et al. "Star-forming Clumps in Local Luminous Infrared Galaxies." 2020, ApJ, 888, 92
25. Fischer, T. et al. "A Dissection of Spatially Resolved AGN Feedback Across the Electromagnetic Spectrum." 2019, ApJ, 887, 200
24. Medling, A. M. et al. "How to Fuel an AGN: Mapping Circumnuclear Gas in NGC 6240 with ALMA." 2019, ApJL, 885, L21
23. Herrero-Illana, R. et al. "The Molecular Gas and Dust Properties of Galaxies from the Great Observatories All-sky LIRG Survey." 2019, A&A, 628, 71

22. Bannister, K. W. et al. "Non-repeating fast radio burst localized to a luminous galaxy." 2019, *Science*, 365, 565
21. Linden, S. T. et al. "A Very Large Array Survey of Luminous Extranuclear Star-Forming Regions in Luminous Infrared Galaxies in GOALS." 2019, *ApJ*, 881, 70
20. Liu, W. et al. "Elliptical Galaxy in the Making: The Dual Active Galactic Nuclei and Metal-enriched Halo of Mrk 273." 2019, *ApJ*, 872, 39
19. Torres-Albà, N. et al. "C-GOALS II. Chandra Observations of the Lower Luminosity Sample of Nearby Luminous Infrared Galaxies in GOALS." 2018, *A&A*, 620, 140
18. Treister, E. et al. "Optical, Near-IR and Sub-mm IFU Observations of the Nearby Dual AGN Mrk 463." 2018, *ApJ*, 854, 83
17. Riess, A. G. et al. "Type Ia Supernova Distances at $z > 1.5$ From the Hubble Space Telescope Multi-Cycle Treasury Programs: The Early Expansion Rate." 2018, *ApJ*, 853, 126
16. Larson, K. L. et al. "Morphology and Molecular Gas Fractions of Local Luminous Infrared Galaxies as a Function of Infrared Luminosity and Merger Stage." 2016, *ApJ*, 825, 128
15. Stierwalt, S. et al. "Mid-infrared Properties of Luminous Infrared Galaxies. II. Probing the Dust and Gas Physics of the GOALS Sample." 2014, *ApJ*, 790, 124
14. Rodney, S. et al. "Type Ia Supernova Rate Measurements to Redshift 2.5 from CANDELS: Searching for Prompt Explosions in the Early Universe." 2014, *AJ*, 148, 13
13. Graur, O. et al. "Type-Ia Supernova Rates to Redshift 2.4 from CLASH: the Cluster Lensing And Supernova survey with Hubble." 2014, *ApJ*, 783, 28
12. Wang, J. et al. "Fast and Furious: Shock Heated Gas as the Origin of Spatially Resolved Hard X-ray Emission in the Central 5 kpc of the Galaxy Merger NGC 6240." 2014, *ApJ*, 785, 55
11. Stierwalt, S. et al. "Mid-infrared Properties of Nearby Luminous Infrared Galaxies. I. Spitzer Infrared Spectrograph Spectra for the GOALS Sample." 2013, *ApJS*, 206, 1
10. Mazzarella, J. et al. "Investigation of Dual Active Nuclei, Outflows, Shock-heated Gas, and Young Star Clusters in Markarian 266." 2012, *AJ*, 144, 125
9. Iwasawa, K. et al. "C-GOALS: Chandra observations of a complete sample of luminous infrared galaxies from the IRAS Revised Bright Galaxy Survey." 2011, *A&A*, 529, 106
8. Iwasawa, K. et al. "The location of an active nucleus and the soft X-ray shadowing by a tidal tail in the ULIRG Mrk 273." 2011, *A&A*, 528, 137
7. Petric, A. et al. "Mid-Infrared Spectral Diagnostics of Luminous Infrared Galaxies." 2011, *ApJ*, 730, 28
6. Haan, S. et al. "The Nuclear Structure in Nearby Luminous Infrared Galaxies: HST NICMOS Imaging of the GOALS Sample." 2011, *AJ*, 141, 100

5. Inami, H. et al. "The Buried Starburst in the Interacting Galaxy II ZW 096 as Revealed by the Spitzer Space Telescope." 2010, AJ, 140, 63
4. Howell, J. et al. "The Great Observatories All-Sky LIRG Survey: Comparison of Ultraviolet and Far-Infrared Properties." 2010, ApJ, 715, 572
3. Armus, L. et al. "GOALS: The Great Observatories All-sky LIRG Survey." 2009, PASP, 121, 559
2. Aspin, C. et al. "V1647 Orionis: Reinvigorated Accretion and the Re-Appearance of McNeil's Nebula." 2009, ApJ, 692, 67
1. MacArthur, L. A. et al. "The Evolutionary History of Galactic Bulges: Photometric and Spectroscopic Studies of Distant Spheroids in the GOODS Fields." 2008, ApJ, 680, 70

Selected Non-Refereed Publications

12. Koss, M.; U, V. et al. "Black Hole Growth in Mergers and Dual AGN." 2019, Astro2020 Decadal Survey, BAAS, 51, 504
11. Kelley, L. Z. et al. "Multi-Messenger Astrophysics with Pulsar Timing Arrays." 2019, Astro2020 Decadal Survey, BAAS, 51, 490
10. Gültekin, K. et al. "Black Holes Across Cosmic Time." 2019, Astro2020 Decadal Survey, BAAS, 51, 287
9. Lopez-Rodriguez, E. et al. "Tracing the Feeding and Feedback of Active Galaxies." 2019, Astro2020 Decadal Survey, BAAS, 51, 138
8. Skidmore, W. et al. "Thirty Meter Telescope Detailed Science Case: 2015." 2015, RAA, 15, 1945
7. U, V. et al. "Keck IFU Observations of Mrk 273." 2013, ASPC, 477, 69
6. Tan, Q.; Gao, Y.; Wang, Z.; U, V. "High resolution SMA imaging of (ultra)-luminous infrared galaxies." 2012, IAUS, 284, 471
5. U, V. et al. "High-Resolution Mapping of CO(3-2) in NGC 6240." 2011, ASPC, 446, 97
4. Morzinski, K. et al. "Circuit Design: An inquiry lab activity at Maui Community College." 2010, ASPC, 436, 295
3. U, V. and Sanders, D. B. "Spectral Energy Distributions of LIRGs." 2010, IAUS, 267, 143
2. Sanders, D. B.; Kartaltepe, J. S.; Kewley, L. J.; U, V.; et al. "Luminous Infrared Galaxies and the Starburst-AGN Connection." 2009, ASPC, 408, 3
1. U, V. et al. "Quantitative Spectral Analysis of BA Supergiants in M33." 2007, IAUS 250, *Massive Stars as Cosmic Engines*

Talks and Seminars

Invited Talks and Colloquia

- Apr 2020 ARC seminar, Queen's University Belfast (online due to COVID-19)
- Feb 2020 Special colloquium, New Mexico State University, Las Cruces, NM
- Feb 2020 Joint NRAO/UVa Colloquium, NRAO / University of Virginia, Charlottesville, VA
- Sep 2019 Astrophysics Colloquium, University of California, Santa Barbara, Santa Barbara, CA
- Sep 2019 Astronomy Seminar, Texas A&M University, College Station, TX
- Aug 2019 Lick Observatory Summer Series: Evening with the Stars, Mount Hamilton, CA
- Jun 2019 Special colloquium, National Optical Astronomy Observatory, Tucson, AZ
- Apr 2019 Special colloquium, University of Melbourne, Victoria, Australia
- Feb 2019 Colloquium, Pomona College, Claremont, CA
- Feb 2019 Special colloquium, University of Chicago, Chicago, IL
- Feb 2019 Special colloquium, University of Kansas, Lawrence, KS
- Feb 2019 Special colloquium, Rochester Institute of Technology, Rochester, NY
- Aug 2018 Lick Observatory Summer Series: Music of the Spheres, Mount Hamilton, CA
- Jul 2018 Riverside Astronomical Society, La Sierra University, Riverside, CA
- Jun 2018 TAPIR Seminar, California Institute of technology, Pasadena, CA
- Feb 2018 Astrophysics seminar, University of California, Irvine, Irvine, CA
- Feb 2018 Special colloquium, University of California, Santa Cruz, Santa Cruz, CA
- Oct 2017 Bash Symposium, University of Texas, Austin, Austin, TX
- Sep 2017 Lunch Talk, Carnegies Observatories, Pasadena, CA
- Aug 2017 Special colloquium, University of Southern California, Los Angeles, CA
- Jun 2017 Institute for Astronomy 50th Anniversary, Kaneohe, HI
- Mar 2017 Cosmology seminar, University of California, Davis, Davis, CA
- Mar 2017 Special colloquium, Space Telescope Science Institute, Baltimore, MD
- Feb 2017 Astronomy seminar, University of California, Riverside, Riverside, CA
- Feb 2017 Special colloquium, University of Missouri, Columbia, MO
- Mar 2016 Synergistic Science in the Radio Regime, Carnegie Observatories, CA
- Mar 2016 CASS Seminar, University of California, San Diego, San Diego, CA
- May 2015 Colloquium, National Central University, Taiwan
- Apr 2015 Seminar, The University of Hong Kong, Hong Kong
- Apr 2015 Colloquium, National Tsing Hua University, Taiwan
- Apr 2015 Colloquium, Academia Sinica Institute of Astrophysics and Astronomy, Taiwan
- Mar 2015 Public lecture, Journey Through The Universe, Hilo, HI
- Dec 2014 Public lecture, University of California, Riverside, Riverside, CA
- Nov 2014 Science talk, Canada-France-Hawaii Telescope, Kamuela, HI

Apr 2013 Seminar, University of Groningen, The Netherlands
 Apr 2013 FIRSED2013, Amsterdam, The Netherlands
 Dec 2011 Special seminar, Submillimeter Array, Cambridge, MA
 Nov 2011 Extragalactic seminar, University of California, Los Angeles, Los Angeles, CA
 Nov 2011 Lunch talk, Carnegie Observatories, Pasadena, CA
 Nov 2011 Astronomy seminar, University of California, Riverside, Riverside, CA
 Nov 2011 Tea talk, California Institute of Technology, Pasadena, CA
 Aug 2011 Lunch talk, National Radio Astronomy Observatory, Charlottesville, VA
 Aug 2011 OIR seminar, Harvard-Smithsonian Center for Astrophysics, Cambridge, MA
 May 2010 Seminar, Purple Mountain Observatory, Nanjing, China
 Mar 2010 Science talk, Canada-France-Hawaii Telescope, Kamuela, HI

[Contributed Talks](#)

Jan 2020 American Astronomical Society 235th Meeting, Honolulu, HI
 Sep 2019 Keck Science Meeting, UCLA, Los Angeles, CA
 Jan 2019 Extremely Big Eyes on the Early Universe, UCLA, Los Angeles, CA
 Jan 2019 American Astronomical Society 233rd Meeting, Seattle, WA
 Dec 2018 Thirty Meter Telescope Science Forum, Pasadena, CA
 Jul 2018 Chinese Academy of Sciences - The National Academies 8th Forum for New Leaders in Space Science, Pasadena, CA
 Jan 2018 Chinese Academy of Sciences - The National Academies 7th Forum for New Leaders in Space Science, Guangzhou, China
 Aug 2017 Galaxy Formation and Evolution in Southern California, Caltech, Pasadena, CA
 Apr 2017 President's Postdoctoral Fellowship Program Academic Retreat, Lake Arrowhead, CA
 Jan 2017 American Astronomical Society 229th Meeting, Grapevine, TX
 Aug 2016 Mapping the Pathways of Galaxy Transformation Across Time and Space, Avalon, CA
 Nov 2015 50 years of Infrared Astronomy, Caltech, Pasadena, CA
 Mar 2015 Unveiling the AGN-Galaxy Evolution Connection, Puerto Varas, Chile
 Jan 2015 American Astronomical Society 225th Meeting, Seattle, WA
 Sep 2014 Riverside Postdoctoral Association Symposium, UC Riverside, Riverside, CA
 Jul 2014 Thirty Meter Telescope Science Forum, Tucson, AZ
 Nov 2012 Binary Black Holes & Dual AGN, Tucson, AZ
 Jan 2012 American Astronomical Society 219th Meeting, Austin, TX
 Oct 2011 Galaxy Mergers in an Evolving Universe, Hualien, Taiwan
 Sep 2011 Keck Science Meeting, Caltech, Pasadena, CA
 Jul 2011 NASA Harriett Jenkins Fellowship Annual Meeting, NASA Ames, Moffett Field, CA
 Oct 2010 Galaxy Evolution: Infrared to Millimeter Wavelength Perspective, Guilin, China

Jan 2010 American Astronomical Society 215th Meeting, Washington, DC
 Aug 2008 Asian-Pacific Regional IAU Meeting, Kunming, China

Telescope Time

2005–2020	Keck – OSIRIS, DEIMOS, NIRC2, KCWI, MOSFIRE, LRIS, NIRES	43n, 10n as PI
2015–2020	Lick – Kast	19n
2019–2020	ALMA	18h
2009–2016	Gemini – NIFS	2n, 20h as PI
2010–2011	SMA	11n, 17t as PI
2009–2011	JCMT – HARP, RxA3	7n, 48h as PI
2009	CSO – Rx, CHARCII	4n, 3n as PI
2009	Subaru – Suprime-Cam	1n
2008	UH2.2m – Tek	11n, 8n as PI
2008	UKIRT – CGS4, UFTI	9n, 3n as PI
2005	Whipple – FAST	3n

Teaching and Mentoring

Formal Teaching

2009 **Astronomy 110 Instructor**, *University of Hawaii at Manoa*, Co-taught an introductory summer course including designing a curriculum with inquiry-based activities.
 2009 **ISEE/CfAO Professional Development Program**, *Maui Community College*, Attended workshops and designed an inquiry-based lab activity for electrical engineers.
 2006 **Astronomy 1 Undergraduate Teaching Assistant**, *Caltech*, Led discussion sessions reinforcing material taught in lectures through problem-solving and other activities.

Research Mentoring

2020–Present **Liam Hunt**, *UCI Undergrad*.
 2020–Present **Akshay Gowrishankar**, *Caltech Undergrad, SURF Program*, co-advising with George Privon.
 2019–Present **Ansh Vashisth**, *Orange County School of the Arts*.
 2019 Summer **Bailey Liu**, *Orange County School of the Arts and Regeneron Top 300 Scholar*, (now Woodrow Wilson Undergrad Research Fellow at Johns Hopkins University).
 2016–2017 **Alex Vogler**, *UCI Undergrad*, co-advised with Aaron Barth, (now grad at UC Davis).
 2013–2015 **Laura DeGroot née Green**, *UCR Grad*, co-advised with Bahram Mobasher, (now Visiting Assistant Professor of Physics at The College of Wooster).
 2012–2015 **Shoubaneh Hemmati**, *UCR Grad*, co-advised with Bahram Mobasher, (now science staff at IPAC).

- 2013–2015 **Armeen Mobasher**, *Riverside STEM Academy*, co-advised with Laura DeGroot, (now undergrad at UC Riverside).
- 2013–2015 **Alex Herrera**, *Riverside STEM Academy*, co-advised with Laura DeGroot, (now undergrad at MIT).
- 2014–2015 **Elizabeth Fletes**, *Riverside STEM Academy*, co-advised with Laura DeGroot.
- 2013 Summer **Nathan Sherrier**, *Riverside STEM Academy*, co-advised with Laura DeGroot.
- 2009 Summer **Michele Dufault**, *Yale Undergrad, IfA REU Program*, (deceased).

Professional Service

- 2017–Present Panel Reviewer and Chair, *NASA ADAP, HST, Swift*
- 2017–Present UCI Advisory Council on Campus Climate, Culture, and Inclusion
- 2017–Present UCI Committee on Inclusive Excellence
- 2015–Present UCI Women in Physics and Astronomy Executive Committee
- 2014–Present Thirty Meter Telescope International Science Development Team
- 2012–Present Thirty Meter Telescope IRMS Science Team
- 2010–Present Journal Reviewer, *Astr. & Space Sci., EPS, ApJ, MNRAS, A&A*
- 2020 Scientific Organizing Committee and Session Chair, Keck Science Meeting, *Pasadena, CA*
- 2020 Scientific Organizing Committee and Session Chair, Galaxy Formation and Evolution in the Era of Roman Space Telescope, *Baltimore, MD*
- 2020 Leader and Organizer, JWST Training Workshop, *Irvine, CA*
- 2020 Scientific Organizing Committee Chair, Extreme Galactic Nuclear Activity – Ultraluminous Starbursts and AGN, *Honolulu, HI*
- 2019–2020 Organizing Committee, *CUWiP 2020, Irvine, CA*
- 2018–2020 Chairperson, *Vejar Elementary School Site Council, Walnut, CA*
- 2019 External Reviewer, *Canadian Time Allocation Committee*
- 2019 Session Chair, *Extremely Big Eyes on the Early Universe, UCLA, Los Angeles, CA*
- 2018–2019 US Extremely Large Telescope Program: Galaxy Evolution Workgroup
- 2018 Session Chair, *TMT Science Forum, SMBH session, Pasadena, CA*
- 2016 External Reviewer, *China's Telescope Access Program TAC*
- 2006–2012 Graduate Education and Public Outreach Committee, *IfA*
- 2011 Harvard-Smithsonian Graduate Student Committee, *CfA*
- 2009 Time Allocation Committee, *IfA*
- 2009 Graduate Admissions Committee, *IfA*
- 2007 Local Organizing Committee, *IAU 250, Kauai, HI*
- 2003–2006 Student for the Exploration and Development of Space, Executive Committee, *Caltech*

2004–2005 Student Faculty Conference Committee: Physics, Applied Physics, and Astronomy,
Caltech