
Dr. Joseph A. Barranco

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Academic & Research Appointments

San Francisco State University, San Francisco, CA

- Assistant Professor, August 2007 – present
- Co-director of SF-STAR (Supercomputer Facility for Space & Terrestrial Advanced Research)

Harvard-Smithsonian Center for Astrophysics, Cambridge, MA

- Postdoctoral Fellow, Institute for Theory & Computation, August 2005 – July 2007

Kavli Institute for Theoretical Physics, Santa Barbara, CA

- Postdoctoral Fellow, January 2004 – July 2005

Department of Astronomy, University of California, Berkeley

- Graduate Student Researcher, Advisor: Professor Philip S. Marcus, September 1996 – December 2003

Harvard-Smithsonian Center for Astrophysics, Cambridge, MA

- Research Assistant, Advisor: Professor Alyssa A. Goodman, January 1993 – June 1995
- Research Assistant, Advisor: Professor Jonathan E. Grindlay, June 1991 – December 1992

Education

University of California, Berkeley

- Ph.D. May 2004, Astrophysics; M.A. December 1996, Astronomy
- Thesis: *Theory and Numerical Simulation of Three-Dimensional Vortices in Protoplanetary Disks*
- Advisor: Professor Philip S. Marcus

Harvard University, Cambridge, MA

- A.B. 1993, Physics, Astronomy & Astrophysics, *Magna Cum Laude*
- Thesis: *Velocity Coherent Structure in the Dense Cores of Dark Molecular Clouds*
- Advisor: Professor Alyssa A. Goodman

Milford High School, Milford, MA

- June 1989, Valedictorian, National Honor Society, President of Theatre Workshop, Eagle Scout

Honors & Awards

- NASA Group Achievement Award SIM Planet Finding Capability Study Team, August 2010: “For successful completion of the study of the detection capability of an astronomical mission searching for terrestrial planets in habitable zones of nearby stars.”
- San Francisco State University Presidential Award for Faculty Scholarship, Spring 2010
- American Physical Society Nicholas Metropolis Award
for Outstanding Doctoral Thesis Work in Computational Physics, 2006
- U.C. Berkeley Outstanding Graduate Student Instructor Award, 1998
- John Harvard Scholarship, 1991, 1993, Harvard College Scholarship, 1992

Grants & Fellowships

- NSF Astronomy & Astrophysics Research Grants, November 2009.
Reviews: (1) Excellent, (2) Excellent. Status: **Awarded** September 2010.
\$425,881 for 3-year period from 09/15/2010 – 09/14/2013.
- National Science Foundation Astronomy & Astrophysics Postdoctoral Fellowship (\$194,000), 2003–2007
- U.C. Berkeley Center for Integrative Planetary Studies Grant Winner (\$17,500), 2001–2002
- National Science Foundation Graduate Fellowship, 1996–1999

Professional Societies & Service

- American Astronomical Society (Division for Planetary Sciences)
- American Physical Society (Divisions of Astrophysics, Computational Physics, Fluid Dynamics)

- American Geophysical Union
- Anacapa Society (Theoretical/Computational Physicists at Primarily Undergraduate Institutions)
- Reviewer, NASA & NSF proposals for grants and fellowships
- Referee, The Astrophysical Journal, Journal of Computational & Applied Mathematics, Physics of Plasmas, Monthly Notices of the Royal Astronomical Society

Teaching Experience

Department of Physics & Astronomy, San Francisco State University

- Astronomy 400/700 (Stellar Astrophysics), Spring 2011
- Physics 220 (General Physics with Calculus I), Fall 2010, Fall 2009, Spring 2009, Fall 2008, Fall 2007
- Physics 330 (Analytic Mechanics I), Fall 2010, 2009, 2008
- Physics 712 (Physics of Plasmas, graduate level), Spring 2011, 2009
- Physics 722 (Astrophysics, graduate level), Spring 2008

Department of Astronomy, Harvard University

- Instructor: Astronomy 191 (Astrophysics Laboratory), Spring 2006
- Taught undergraduates how to use 16-inch telescope and CCD to make observations of eclipsing binary stars, and to reduce & analyze data to determine orbital properties.

Department of Physics, University of California, Santa Barbara

- Lecturer: Physics 3 (Mechanical Waves, Electricity), Summer 2004

San Quentin Prison College Program through Patten College

- Instructor: Statistics, Spring 2001; Astronomy, Summer 2001; Algebra, Fall 2001

Department of Physics, University of California, Berkeley

- Group Tutor: Physics 137a (Intro. Quantum Mechanics), Fall 2000
- Graduate Student Instructor: Physics 7A (Intro. Mechanics), Spring 2000 (Dr. B. Birkett)
- Graduate Student Instructor: Physics 7B (Intro. Electricity & Magnetism), Fall 1999 (Dr. B. Birkett)

Department of Astronomy, University of California, Berkeley

- Lecturer: Astronomy 7B (Intro. Astrophysics II), Spring 1998
- Head Graduate Student Instructor: Astronomy 7A (Intro. Astrophysics I), Fall 1997 (Prof. J. Graham)
- Head Graduate Student Instructor: Astronomy 10 (Intro. Astronomy), Spring 1996 (Prof. J. Silk)
- Graduate Student Instructor: Astronomy 10 (Intro. Astronomy), Fall 1995 (Prof. F. Shu)

Upward Bound Program at University of California, Berkeley

- Upward Bound is a mentoring/tutoring program for socio-economically disadvantaged high school students who are trying to become the first in their families to attend college.
- Math/Science Instructor: Math & Science Summer Academy, Summer 1996, 1997
- Math/Science Instructor: Saturday College, Fall 1996, Spring 1997

Division of Engineering and Applied Sciences, Harvard University

- Teaching Fellow: Applied Math 105 (Applied Math for Scientists/Engineers), Spring 1993, Fall 1993, Spring 1994, Spring 1995

Department of Mathematics, Harvard University

- Course Assistant: Math 1b, 21a (Calculus), Fall 1990, Spring 1991

Education & Public Outreach

- **Science Education Consultant, SF Unified School District**, August 2009 – present. Develop & lead professional development seminars for public school teachers as part of Working to Improve Science Education (WISE) Summer Institute.
- **Science Education Consultant, Banneker Charter Public School**, Fall 2006 – Fall 2007: I developed professional development workshops to help train the teachers at this math/science-focused K-8 public charter school that serves a 100% minority (mostly African-American & Latino) student population.
- **Workshop Leader for Graduate Student Instructor Teaching & Orientation Conference**, Fall 2000 & Fall 2001: Led workshops to train incoming graduate students at Berkeley on how to be more effective teachers in the physical sciences.

- **Graduate Student Instructor/Tutor for Physics Scholars Program (PSP)**, August 1999 – December 2000: PSP is a tutoring/mentoring program for women and minority (African-American, Latino, & Asian) undergraduate students in the physical sciences and engineering.
- **Berkeley Black Graduate Engineering & Science Students Association Science Fair**, 1997-1998: Mentored high-school students from Oakland Technical High School.
- **Black & Latino Violence Prevention Project**, Stiles Hall, 1996–1998: Mentored three “at-risk” young men from inner-city Oakland.
- **American Association for the Advancement of Science – Boston Black Church Project (AAAS–BBC)**, 1994-1995: Site coordinator; developed hands-on, interactive science curriculum for after-school tutoring programs that outreached to African-American/Latino youth in the city of Boston.
- **Bruce Wall Ministries, Inc.**, 1993–1995: Program Coordinator and Lead Tutor at PROJECT 21, an after-school tutoring program for inner-city youth in Boston; Mentor in Gangs Anonymous, a support group for young men formerly involved in gangs; Science Coordinator for Camp Ozioma, a summer program for 50 inner-city youth.

Current Research Projects

Kelvin-Helmholtz Instability of Settled Dust Sublayers in Protoplanetary Disks

- As dust settles into the midplane of a protoplanetary disk, it creates a vertical shear profile: dust-rich gas in the midplane orbits faster than the dust-depleted gas above and below. This shear can suffer Kelvin-Helmholtz instability which re-mixes and destroys the dust-layer. I am in the process of carrying out 3D simulations of this phenomenon and assessing its impact on the early stages of planet formation.
- Collaborators: Eugene Chiang, Aaron Lee (U.C. Berkeley)

Smooth Particle Hydrodynamic (SPH) Simulations of Collisions of Large Bodies (Planetesimals, Planet Embryos, Planets, Comets, Asteroids)

- We are in the process of modifying the GADGET-2 SPH code (originally developed for cosmological simulations) so that it can handle collisions of rocky and icy materials. The goal is to carry out simulations of large body collisions in the late stages of planet formation.
- Collaborators: R. Marcus, Z. Leinhardt, D. Sasselov, L. Hernquist, S. Stewart (Harvard University)

Dust-trapping 3D Vortices in Protoplanetary Disks

- This is an extension of my Ph.D. thesis work. Vortices are efficient at capturing and trapping dust grains. We are exploring whether this is a viable mechanism to seed the formation of planetesimals.
- Collaborators: X. Asay-Davis (Los Alamos), P. Marcus (U.C. Berkeley)

Turbulent Dissipation in Shearing Convection Zones in Cool Stars and Giant Planets

- Turbulent (eddy) viscosity is often considered to be the main mechanism responsible for the dissipation of tides and oscillations in convection zones of cool stars and planets. We are carrying out 3D simulations of tidally sheared turbulent convective zones to constrain the magnitude of dissipation, and the role this dissipation plays in the circularization of orbits.
- Collaborators: K. Penev, D. Sasselov (Harvard University)

3D Simulations of the Great Red Spot and Other Planetary Vortices

- How deep does the Great Red Spot (GRS) go? How does the GRS sustain itself over more than 300 years (at least)? How do such gargantuan storms form in the first place? We are carrying out 3D simulations of the GRS and its interaction with zonal flows to answer some of the mysteries of long-lived planetary vortices.
- Collaborators: X. Asay-Davis (Los Alamos), P. Marcus (U.C. Berkeley)

Magnetohydrodynamic (MHD) Simulations of Protoplanetary Disks

- The combination of Keplerian rotation/shear and magnetic fields is known to be unstable to magnetorotational instability (MRI) which results in turbulence and angular momentum transport. However, protoplanetary disks are relative cool and neutral, and it is unclear to what extent MRI can operate in this context. We are carrying out 3D high-resolution simulations of MRI in protoplanetary disks to determine the extent of coupling between matter and fields, and the effect on turbulent diffusion of dust particles.
- Collaborators: P. Marcus (U.C. Berkeley)

Multiplicity & Variability of Kuiper Belt Objects (KBOs)

- We are using the Magellan 6.5 m telescope at Las Campanas, Chile (July 2006, April 2007) to study the variability (due to rotation and surface anomalies) and multiplicity (frequency of moons) of known KBOs. The goal of this work is to put constraints on the formation and dynamics of such systems, which ultimately gives clues to the collisional dynamics in the early Solar System.
- Collaborators: B.S. Gaudi (Ohio State), D. Trilling (U. Arizona), M. Holman (CfA)

A Search for Transiting Planets in M37

- In January 2006, we observed the M37 cluster with the MMT at Mt. Hopkins, AZ for 20 consecutive nights to search for transiting Jupiter and Neptune size planets. Planets discovered by transits yield the radius of the planet and the inclination of the orbit. In conjunction with measuring the radial velocity via the Doppler effect, one can obtain the mass and average density of the planet as well.
- Collaborators: J. Hartman, M. Holman (CfA), B.S. Gaudi (Ohio State)

Nonlinear Interactions of Internal Gravity Waves in Atmospheres & Oceans

- H. Swinney has a rotating tank in which he carries out experiments of the generation and propagation of nonlinear internal gravity waves. We carry out numerical simulations of the same phenomena to elucidate the roles that stratification & rotation play in the wave dynamics.
- Collaborators: H. Swinney (U. Texas, Austin), P. Marcus (U.C. Berkeley)

Publications

- **Barranco, J.**, Marcus, R., Stewart, S., Sasselov, D., 2011, "Smooth-particle Hydrodynamic Simulations of Accretion of Water Ice Embryos onto Proto-Earth." In preparation.
- **Barranco, J.**, Ryan, M., Gaudi, B.S., Trilling, D., Holman, M. 2011, "A Survey of Kuiper Belt Objects for Photometric Variability and Binarity." In preparation.
- Lee, A., Chiang, E., Asay-Davis, X., **Barranco, J.**, 2010, "Forming Planetesimals by Gravitational Instability: II. How Dust Settles to its Marginally Stable State." *The Astrophysical Journal*, **725**: 1938–1954. eprint arXiv:astro-ph/10100250.
- Lee, A., Chiang, E., Asay-Davis, X., **Barranco, J.**, 2010, "Forming Planetesimals by Gravitational Instability: I. The Role of the Richardson Number in Triggering the Kelvin-Helmholtz Instability." *The Astrophysical Journal*, **718**: 1367–1377. eprint arXiv:astro-ph/10100248.
- Penev, K., **Barranco, J.**, Sasselov, D. 2010, "First Results from New 3D Spectral Simulations of Anelastic Turbulent Convection." Under revision for *The Astrophysical Journal*. eprint arXiv:astro-ph/08105151.
- Penev, K., **Barranco, J.**, Sasselov, D. 2009, "Direct Calculation of the Turbulent Dissipation Efficiency in Anelastic Convection." *The Astrophysical Journal*, **705**: 285–297. eprint arXiv:astro-ph/08105370.
- **Barranco, J.A.** 2009, "Three-Dimensional Simulations of Kelvin-Helmholtz Instability in Settled Dust Layers in Protoplanetary Disks." *The Astrophysical Journal*, **691**: 907–921. eprint arXiv:astro-ph/07114410.
- Hartman, J. D., Gaudi, B. S., Holman, M. J., McLeod, B. A., Stanek, K. Z., **Barranco, J. A.**, Pinsonneault, M. H., Meibom, S., Kalirai, J. S., 2009, "Deep MMT Transit Survey of the Open Cluster M37. IV. Limit on the Fraction of Stars With Planets as Small as $0.3 R_J$." *The Astrophysical Journal*, **695**:336–356. eprint arXiv:astro-ph/08093807.
- Hartman, J.D., Gaudi, B.S., Pinsonneault, M.H., Stanek, K.Z., Holman, M.J., McLeod, B.A., Meibom, S., **Barranco, J.A.**, Kalirai, J.S., 2009, "Deep MMT Transit Survey of the Open Cluster M37. III. Stellar Rotation at 550 Myr." *The Astrophysical Journal*, **691**: 342–364. eprint arXiv:astro-ph/08031488.
- Hartman, J.D., Gaudi, B.S., Holman, M.J., McLeod, B.A., Stanek, K.Z., **Barranco, J.A.**, Pinsonneault, M.H., Kalirai, J.S., 2008, "Deep MMT Transit Survey of the Open Cluster M37. II. Variable Stars." *The Astrophysical Journal*, **675**: 1254–1277. eprint arXiv:astro-ph/07093484.
- Hartman, J.D., Gaudi, B.S., Holman, M.J., McLeod, B.A., Stanek, K.Z., **Barranco, J.A.**, Pinsonneault, M.H., Meibom, S., Kalirai, J.S., 2008, "Deep MMT Transit Survey of the Open Cluster M37. I. Observations and Cluster Parameters." *The Astrophysical Journal*, **675**: 1233–1254. eprint arXiv:astro-ph/07093063.
- Hartman, J.D., Gaudi, B.S., Holman, M.J., McLeod, B.A., Stanek, K.Z. & **Barranco, J.A.** 2007, "A Search for Transiting Hot Planets as Small as Neptune in the Open Cluster M37," ASP Conference Series: "Transiting Extrasolar Planets Workshop" MPA Heidelberg Germany, 25-28 September 2006. Eds: Cristina Afonso, David Weldrake & Thomas Henning. eprint arXiv:astro-ph/0701389

- **Barranco, J.A.** & Marcus, P.S. 2006 “A 3D Spectral Anelastic Hydrodynamic Code for Shearing, Stratified Flows,” *Journal of Computational Physics*, **219**:21–46.
- **Barranco, J.A.** & Marcus, P.S. 2005, “Three-Dimensional Vortices in Stratified Protoplanetary Disks,” *The Astrophysical Journal*, **623**:1157–1170.
- **Barranco, J.A.** & Marcus, P.S. 2004, “Planet Embryos in Vortex Wombs,” in *The Search for Other Worlds: Fourteenth October Astrophysics Conference at the University of Maryland*, AIP Conference Proceedings, **713**:67–70.
- **Barranco, J.A.**, Marcus, P.S., & Umurhan, O.M. 2000, “Scalings and Asymptotics of Coherent Vortices in Protoplanetary Disks,” in *Studying Turbulence Using Numerical Simulation Databases – VIII, Proceedings of the 2000 Summer Program*, Stanford University/NASA–Ames Center for Turbulence Research, p.85–95.
- **Barranco, J.A.** & Marcus, P.S. 2000, “Vortices in Protoplanetary Disks and the Formation of Planetesimals,” in *Studying Turbulence Using Numerical Simulation Databases – VIII, Proceedings of the 2000 Summer Program*, Stanford University/NASA–Ames Center for Turbulence Research, p.97–108.
- **Barranco, J.A.** & Goodman, A.A. 1998, “Coherent Dense Cores. I. NH_3 Observations,” *The Astrophysical Journal*, **504**:207–222.
- Goodman, A.A., **Barranco, J.A.**, Wilner, D.J., & Heyer, M.H. 1998, “Coherence in Dense Cores. II. The Transition to Coherence,” *The Astrophysical Journal*, **504**:223–246.
- Goodman, A.A., **Barranco, J.A.**, Wilner, D.J., & Heyer, M.H. 1998, “Velocity Coherence in Dense Cores,” *Astrophys. Lett. & Comm.*, **37**:109.
- Goodman, A.A., **Barranco, J.A.**, Wilner, D.J., & Heyer, M.H. 1997, “Velocity Coherence in Dense Cores,” in *Star Formation Near and Far: Seventh Astrophysics Conference*, ed. S.S. Holt, L.G. Mundy (Woodbury, N.Y.: AIP Press) **393**:105.
- Goodman, A.A., **Barranco, J.A.**, Wilner, D.J., & Heyer, M.H. 1996, “Velocity Coherence in Dense Cores,” in *CO: Twenty-Five Years of Millimeter-Wave Spectroscopy*, Proceedings of the 170th Symposium of the IAU, Tucson, AZ, May 29–June 5, 1995, ed. W. Latter, S.J.E. Radford, P.R. Jewell, J.G. Mangum, & J. Bally (Dordrecht: Kluwer), p.116.
- Goodman, A.A. & **Barranco, J.A.** 1994, “Velocity Structure in Dense Cores,” in *Clouds, Cores, and Low Mass Stars*, ed. D. Clemens & R. Barvainis (San Francisco: Astronomical Society of the Pacific Conference Proceedings), **65**:57–66.

Invited Talks & Colloquia

- City College of San Francisco, April 22, 2009, “Planet Embryos in Vortex Wombs: The Origins of Planetary Systems.”
- City College of San Francisco, September 9, 2008, “Planet Embryos in Vortex Wombs: The Origins of Planetary Systems.”
- Peninsula Astronomical Society, May 9, 2008, “Planet Embryos in Vortex Wombs: The Origins of Planetary Systems.”
- University of San Francisco, February 27, 2008, “Planet Embryos in Vortex Wombs: The Origins of Planetary Systems.”
- San Mateo County Astronomical Society, November 2, 2007, “Planet Embryos in Vortex Wombs: The Origins of Planetary Systems.”
- University of California, Santa Cruz, October 31, 2007, “Planet Embryos in Vortex Wombs: The Origins of Planetary Systems.”
- California State Polytechnic University, Pomona, February 27, 2007, “Planet Embryos in Vortex Wombs: The Origins of Planetary Systems.”
- San Francisco State University, February 23, 2007, “Planet Embryos in Vortex Wombs: The Origins of Planetary Systems.”
- Nicholas Metropolis Award talk, American Physical Society, March 2006, Baltimore, MD. Barranco, J.A. & Marcus, P.S. “A 3D Spectral Anelastic Hydrodynamic Code for Shearing, Stratified Flows.”
- Haverford College, Department of Physics & Astronomy, February 6, 2006. “Planet Embryos in Vortex Wombs.”
- Olin College of Engineering, Needham, MA, November 2005. “Planet Embryos in Vortex Wombs.”
- Max Planck Institute for Astrophysics, Garching, Germany, December 2004. “Planet Embryos in Vortex Wombs.”
- University of California, Berkeley, Department of Mechanical Engineering, April 2004. “Planet Embryos in Vortex

Wombs.”

- Kavli Institute for Theoretical Physics, University of California, Santa Barbara, February 2004. “Planet Embryos in Vortex Wombs.”
- University of Texas, Austin, Department of Astronomy, October 2003. “The Future of Planet Formation.”
- Lawrence Livermore National Laboratory, January 2003. “Planet Embryos in Vortex Wombs.”
- Canadian Institute for Theoretical Astrophysics, Toronto, ON. January 2003. “Vortices in Protoplanetary Disks and the Formation of Planetesimals.”
- Kavli Institute for Theoretical Physics, University of California, Santa Barbara, December 2002. “Vortices in Protoplanetary Disks and the Formation of Planetesimals.”
- San Francisco State University, Department of Physics & Astronomy, December 2000. “Vortices in Protoplanetary Disks and the Formation of Planetesimals.”

Conference Presentations

- American Physical Society, Division of Fluid Dynamics, November 2010, Long Beach, CA. Barranco, J.A., Lee, A., Chiang, E., Asay-Davis, X. “Dust Settling in Protoplanetary Disks and the Onset of Kelvin-Helmholtz Instability.”
- American Physical Society, Division of Fluid Dynamics, November 2010, Long Beach, CA. Kamal, S., Barranco, J.A., & Marcus, P. “3D Vortices in Protoplanetary Disks.”
- American Astronomical Society, Division of Planetary Sciences, October 2006, Pasadena, CA, Barranco, J.A. “Three-Dimensional Simulations of Kelvin-Helmholtz Instabilities of Dust Sublayers in the Midplanes of Protoplanetary Disks.”
- American Astronomical Society, January 2006, Washington, DC. Barranco, J.A. “Kelvin-Helmholtz Instability in the Dusty Midplane of Protoplanetary Disks.”
- American Astronomical Society, January 2005, San Diego, CA. Barranco, J.A. & Marcus, P.S. “Three-Dimensional Vortices in Stratified Protoplanetary Disks.”
- Ringberg Workshop on Planet Formation: Theory Meets Observation, December 2004, Rottach-Egern, Bavaria, Germany. “Planet Embryos in Vortex Wombs.”
- American Geophysical Union, December 2003, San Francisco, CA. Barranco, J.A. & Marcus, P.S. “Planet Embryos in Vortex Wombs.”
- The Search for Other Worlds: Fourteenth October Astrophysics Conference at the University of Maryland, October 2003, College Park, MD. “Planet Embryos in Vortex Wombs.”
- American Astronomical Society, Division of Planetary Sciences, September 2003, Monterey, CA. Barranco, J.A. & Marcus, P.S. “Planet Embryos in Vortex Wombs.”
- American Astronomical Society, January 2003, Seattle, WA. Barranco, J.A. & Marcus, P.S. “Planet Embryos in Vortex Wombs.”
- American Physical Society, Division of Fluid Dynamics, November 2002, Dallas, TX. Barranco, J.A. & Marcus, P.S. “Planet Embryos in Vortex Wombs.”
- American Astronomical Society, Division of Planetary Sciences, November 2001, New Orleans, LA. Barranco, J.A. & Marcus, P.S. “Vortices in Protoplanetary Disks and the Formation of Planetesimals.”
- American Physical Society, Division of Fluid Dynamics, November 2001, San Diego, CA. Barranco, J.A. & Marcus, P.S. “Vortices in Protoplanetary Disks and Their Role in Planet Formation.”
- American Physical Society, Division of Fluid Dynamics, November 2000, Washington, DC. Barranco, J.A. & Marcus, P.S. “Accumulation of Dust Grains within Vortices and its Role in Planet Formation.”