UC SANTA BARBARA Kavli Institute for Theoretical Physics

Exploring New Frontiers

Impact Report 2018

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Dear Friends,

I joined the Institute for Theoretical Physics nearly twenty years ago as a Permanent Member. Then Director David Gross explained why the move to Santa Barbara would enable me to expand my research and career in new directions. As usual with David, he was right.

When I arrived in 1999, Kohn Hall was already the iconic tower building that greets visitors at the east entrance to UC Santa Barbara. In 2004, the facility was expanded--thanks to financial help from Fred Kavli--so as to accommodate the growth in visiting scholars who now come to the re-named Kavli Institute for Theoretical Physics (KITP) to participate in our programs.

Today, Kohn Hall is laced with chalkboards and dynamic community spaces that encourage interactive scientific exchanges. Physicists who visit the KITP to participate in our programs have the opportunity to cross-fertilize ideas and create new networks that continue long after they leave, which is a powerful method for scientific inquiry and discovery.

As a friend of the KITP, you know this well: that the advancement of theoretical physics and all of science depends on human interactions. It all starts with the programs we create in a strong collaboration with the physics community and our Scientific Advisory Board, a group of prominent physicists from across the country. These programs then nucleate the groups of excellent physicists who come for months of interactions in Kohn Hall. Our new Charles T. Munger Physics Residence now allows our visitors to live together, ensuring the impact of their most precious investment at KITP: their time. Our consideration of both the physical and the intellectual environment is what makes the KITP so unique and impactful.

The growth and impact of the Institute cannot be illustrated in a few pages. Nevertheless, we are excited to share some of the progress and meaningful outcomes the KITP has enabled over the past few years, and to recognize the support we receive from UC Santa Barbara, federal granting agencies, private foundations and extraordinary benefactors. Please come visit us at the KITP. I am confident that you will find the Institute buzzing with inspiration and collaboration. It's an environment that is as dynamic as space itself.

Thank you for your support and enthusiasm for the KITP. Let's continue exploring new frontiers together!



Lars Bildsten

Director of the Kavli Institute for Theoretical Physics Gluck Professor of Theoretical Physics at UC Santa Barbara



The Kavli Institute for Theoretical Physics (KITP) at UC Santa Barbara is the foremost scientific research facility for theorists in physics and allied fields to explore new ideas and to work together intensely on questions at the leading edges of science.

Since its origin in 1979, the KITP's driving force has been the exploration and promotion of new areas of scientific study. We foster international and crossdisciplinary networks, train the next generation of theorists, and engage the public in our collaborative, transformational research.

Here, we strive to stretch the limits of understanding; •Here, our Institute is as dynamic as space itself.

THE KITP EXPLORING NEW FRONTIERS





Far-Reaching Impact

Investing by Intuition

The Troxels gift \$1M to establish the Troxel Family Chair in Theoretical Physics

Call it intuition, call it a hunch, but Doug and Deborah Troxel are betting on a solution that hasn't been discovered yet. They believe the future of clean energy depends on physics.

"It's a gut feel," says Doug. "I do think there is a way of extracting energy from atoms, the smallest building blocks."

The Troxels are investing \$1 million in this provocative possibility. Their endowed chair, the Troxel Family Chair in Theoretical Physics, will support a KITP physicist engaged in fundamental research. Their instinct is that the kind of creative scientific inquiry done at the KITP might some day provide insights into new forms of renewable energy---and like solar, wind, and water energy sources, the Troxels believe the atom holds the key.

"It's future tense," concedes Doug. "It's not what [KITP] is doing right now. I just hope it's in my lifetime."

The Troxels' history with UC Santa Barbara dates back several decades. In fact, Deborah is an alumna who majored in biology.

"I did go to UCSB so my allegiance, of course, was to my university," says Deborah. "I was anxious to get Doug involved there."

Deborah's introduction was fortuitous. Doug gravitated toward physics (he majored in mathematics and minored

in physics at Iowa State University) and therefore KITP was a natural fit. Meeting KITP Director Lars Bildsten and David Gross, Nobel Laureate and Permanent Member of the KITP, served to deepen the Troxels' relationship with the Institute.

"I get something out of it, they get something out of it," remarks Doug, who is founder and former Chief Executive and Chief Technology Officer of Serena Software, Inc. The retired software developer is president of his family foundation, Change Happens, and splits his time between California and Hawaii with Deborah. The Troxels are actively engaged with the KITP community and often attend events and lectures when they are in Santa Barbara.

"You have to trust that what you're doing is the right thing," says Doug. "Philanthropy is like planting a seed and a tree grows up that you might never see."

The Troxels' mission, like their family foundation, is to invest in pioneering programs and forward-thinking projects. Their endowed chair is just another example of their visionary philanthropy.

So how do they know when they've found the right fit for their philanthropic investment?

By intuition.

"We know it when we see it," says Doug.



A Visionary Return on Investment

Carl Feinberg commits \$1.45M to establish a chair in theoretical physics

It's difficult to find a New Yorker more passionate about the KITP than Carl Feinberg. The Founder and CEO of Relational Architects International (a computer software firm based in New Jersey) recently committed \$1.45 million to establish the Carl P. Feinberg Chair in Theoretical Physics. The Feinberg Chair will support a senior faculty member who demonstrates brilliance, creativity, and productivity.

"The KITP attracts the best and the brightest," says Feinberg, "whose record of achievement is significant. One of my hopes, with respect to both the Chair and KITP in general, is that the work done here will gain insights into the fundamental nature of reality."

Feinberg's love of physics started early in childhood - and even though he pursued a career in software programming, the world of physics was never far away. "Physics is an intrinsic part of my DNA," says Feinberg. "When I was a little kid, I could do anything I wanted on my birthday and I opted to go to the Hayden Planetarium. I wanted to be an astronomer then and I still find it fascinating."

Feinberg stayed close to the physics community throughout the years. "Kindred spirits" clustered in spaces where exciting breakthroughs were happening namely, at the Institute for Advanced Study in Princeton (IAS) and the KITP.

"I regard IAS and KITP as very special places that play a vital role in the physics community," says Feinberg, who also endowed a Professorship of Theoretical Physics in the School of Natural Sciences at the IAS. "They're both unique and I feel the two institutions complement and supplement each other."

One of KITP's strengths is its "rapid response" capability. When the 2017 black hole collisions were observed, for example, the KITP quickly organized a program. Physicists and astronomers from around the world convened at the KITP to discuss the astrophysics of the merger.

"The impact of the KITP in relation to its budget and headcount is unrivaled and simply phenomenal," says Feinberg. "When those I support thank me, I say 'You're most welcome. Just do something extraordinary," he adds with hyperbolic humor.

The Feinberg Chair will support a new permanent faculty member of the Institute, matching the likes of Lars Bildsten, who holds the Frederick W. Gluck Chair in Theoretical Physics, David Gross who holds the Chancellor's Chair in Theoretical Physics, Boris Shraiman who holds the Susan F. Gurley Chair in Theoretical Physics and Biology, and Leon Balents who holds the Pat and Joe Yzurdiaga Chair in Theoretical Physics.

Feinberg's investment is an indicator of KITP giving trends - namely, that donors are investing for long-term impact. Feinberg sees his Chair as an investment in civilization that will add to humanity's collective knowledge.

"Civilization is a team sport," says Feinberg. "We're all in it together."





A Friend for New Knowledge

Virginia Castagnola-Hunter shares inspiration behind her philanthropy

Albert Einstein once said that "imagination is more important than knowledge." For Virginia Castagnola-Hunter, that statement rings true.

"What really inspires me is exploring how things work in our universe and what is possible in the future," explains Castagnola-Hunter. "We need the KITP to convene the brightest minds and push the boundaries of what we know."

For boundary-pushing, there's no better example than Virginia herself. As a native Santa Barbaran, Virginia (better known as "Ginnie") has traveled extensively and explored nearly every discipline. After graduating from Stanford University, she studied International Relations at Georgetown University's School of Foreign Service (she was one of the first three women invited to enroll in the formerly all-male school). She also did a stint on a political science scholarship at Mills College and three years of graduate study at UC Santa Barbara in Italian Renaissance Art History, with a minor in Greek.

While traveling the world many times over, Ginnie's camera lens was focused on archeological sites including Machu Picchu in Peru; Angkor Wat (Khmer ruins) in Cambodia; Persepolis, capital of the ancient Persian Empire; Chichén Itzá, the ruined Mayan City in Yucatán; Easter Island in Chile; Aphrodisias in Turkey; the temples of Sicily, and other historic sites in Greece and Albania. Having studied the variations and mysteries of these impressive ancient sites, Ginnie especially looks forward to the discoveries scientists are making as they explore our uncharted universe.

"I love learning about the discoveries of new planets and distant galaxies," says Castagnola-Hunter. "It puts you in a positive mood to look at the stars and to imagine the possibility of what we have to look forward to in the future."

Ginnie's expansive worldview was shared with KITP Nobel Laureate Walter Kohn, who became a good friend of hers over the years. She once asked Kohn if she could support KITP's "Chalk Talks." "So many brilliant physicists visit Kohn Hall from everywhere in the world to collaborate, so it seemed like a win-win situation to connect them with inquiring members of our local community," says Ginnie.

Today, the Friends of KITP is a 300-person community, whose interests are uniquely multidisciplinary. Friends enjoy opportunities to interact with scientists through events and quarterly "Chalk Talks," where informal discussion is encouraged.

"I truly love what the KITP does and it's been an honor for me to support it and to be a part of such an incredible community," says Ginnie. "There is no doubt that I have received much more than I have given."

What Castagnola-Hunter has given is generous. Her support, along with other members of the Friends of KITP, sustains programming and promotes the Institute's trademark approach: interdisciplinary research that's inspired by possibilities.

"Having traveled all over the world, I am so proud that we have this incredible intellectual asset right here in my hometown of Santa Barbara," says Castagnola-Hunter. "It is hugely inspiring and I have loved every minute of being involved with the KITP. I think the biggest contribution comes from a multitude of people from different backgrounds working together."

Indeed, Friends of the KITP could very well mirror the Institute they support: their collective efforts, united by a shared vision, serve to stimulate discovery.

As Castagnola-Hunter puts it: "Everybody's ideas are pouring in with their unique cultural backgrounds, and they become a cohesive team working together in pursuit of new knowledge. It really is a brilliant model. It's so important that it be sustained."



Science at the Edge of Discovery

KITP's visiting scientists cite the Institute as the catalyst for new ideas

"I have truly...lived off the ideas and collaborations that were initiated at KITP."

Mehran Kardar is a statistical physicist known for the Kardar-Parisi-Zhang equation, a widely applicable model of a randomly growing interface. Kardar counts himself among the many statistical physicists who find research questions in biology, a development he credits in part to KITP.

"It's a good way to initiate collaborations in various topics and meet people that you wouldn't have interacted with otherwise," he says.

One of Kardar's KITP visits, along with his work with Leonid Mirny, galvanized an MIT graduate course in statistical physics in biology. The course links to many KITP seminars on the subject, and its impact reaches beyond MIT through the Institute's OpenCourseware website.

In 2008, Kardar co-organized a KITP program called "The Theory and Practice of Fluctuation-Induced Interactions." The program inspired his graduate student, Sahand Jamal Rahi, who subsequently transitioned to biophysics and will start his own lab in Lausanne in 2018.

"The KITP is a 'breakthrough accelerant,' an enzyme for discovery."

Juna Kollmeier researches the emergence of structure in the universe. As the first theoretician at the Carnegie Observatories, she started its program in theoretical astrophysics.

Kollmeier's work spans spatial scales from black holes to the Intergalactic Medium, and she uses both computational and analytical theory in close dialog with observational results. Her first visit to the KITP was as a graduate student affiliate in the "Galaxy-Intergalactic Medium Interactions" program. She believes opposing ideas can accelerate scientific discovery and views KITP as a crucial safe space for constructive debate.

"That really set my view because there were a very significant fraction of the best people in the field, all rapping about this one thing and debating with each other!"

According to Kollmeier, there is an abundance of high-quality data, revealing anomalies that beg for resolution. There is a real sense of imminent breakthrough, and each disparate area contains an element of that revolutionary event.

"We all want to see that happen in our lifetimes," she shares.



MEHRAN KARDAR

Francis Friedman Professor of Physics at the Massachusetts Institute of Technology

JUNA KOLLMEIER

Astrophysicist at The Carnegie Observatories Director of the Sloan Digital Sky Survey-V



Physicists Who Stay Together, Play Together

How one philanthropist's investment leads to far-reaching progress

"He knew better than I did how well it'd work out with respect to constant social interactions."

That's Lars Bildsten, Director of KITP, talking about investor Charles T. Munger. The philanthropist recently gifted \$65 Million to build the Munger Physics Residence, a new visitor housing facility for KITP that mixes work with play.

"The residence was built to solve a lot of problems," says residence manager James Brill. "We're furnished all the way down to the whisks."

The Munger Physics Residence offers not only whisks but several amenities that suit daytime and nighttime activities for KITP participants. Outfitted to accommodate 61 people (which can include visiting scholars' spouses and children), the residence is a premier living and working environment. It boasts fully furnished apartments, blackboards, barbecues, music rooms, ping-pong tables, and children's play rooms — all the features and places that foster organic social interactions. Indeed, the residence was built with ease in mind, intended to alleviate the stress related to finding housing in the Santa Barbara community.

"Before [the Munger Physics Residence], you'd get invited to attend a workshop at the KITP and then you were faced with trying to figure out where you were going to live," says Leo Radzihovsky, professor of physics at the University of Colorado at Boulder. Radzihovsky is a repeat visitor to the KITP, and shares how housinghunts can lead to undue stress and uncertainty. "If you're trying to do creative work but are not feeling inspired, inundated with finding good housing, then it's difficult to be creative."

Brill agrees and adds: "No one really feels at home in a conference hotel."

The housing facility was inspired by Munger himself, who asserts that physicists gain enormously from knowing each other and socially connecting. Those interactions are more likely to happen in informal settings that take place during the weekends or after work hours. Now with the residence, physicists are able to exchange ideas at any hour of the day.

"UCSB has by far the most important program for visiting physicists in the world," says Munger. "Leading physicists routinely are coming to the school to talk to one another, create new stuff, cross-fertilize ideas."

The residence does a good job of addressing all facets of temporary relocation — and that includes the needs of family members, too. According to Louise Parsons Chini, research professor of geographical sciences and wife of KITP visiting scholar Greg Chini, everything about the residence is a great experience. Guests receive a welcome basket filled with groceries on their first day of arrival, and family interactions take place within the private and public spaces of the housing facility.

"You're actually seeing in a short amount of time the result of [Munger's] gift," reflects Brill. In just under three years, Munger's \$65 Million gift spun out the design, construction, and opening of a brand new residence, which promises countless collaborations that will advance the field of physics for years to come.

"I have nothing but gratitude to Charlie Munger and other philanthropists who value science and think about making a difference," reflects Radzihovsky.

Adds Bildsten: "We are already seeing increased collaborations and scientific progress."

And that's precisely the vision Charlie Munger had when he made his investment.



The 'Summer Camp' Spirit

KITP staff play a critical role in the KITP experience

If the word "physicist" conjures the image of an isolated scientist, think again: international scholars aren't sojourning in Santa Barbara for a lonely getaway.

"People come here because they want to interact. That's the whole point: to form new connections," says Maggie Sherriffs, KITP Special Programs and Evaluation Manager.

Sherriffs echoes the sentiments of her colleagues who represent a contingent of the KITP community. Together, KITP staff not only serve the Institute but significantly contribute to the KITP experience.

"I always greet them with a smile," says Bibiana Rojas, KITP Visitor Services Assistant. "Physicists are amazing people."

For Rojas, going above and beyond is her trademark approach. She handles the little things that arise for KITP's visitors as well as bigger challenges like transportation and healthcare.

"KITP programs are simply one of the kind," reflects one KITP alumnus. "The scientific quality is high, the support and supporting staff is unparalleled, [and] the ease of settling down and working out the practicalities makes everything smooth. It is a model for how families can be treated and made to feel welcome."

"Everyone plays a role," explains Rojas. "Physicists require the freedom and space to think and be creative. If not for staff, our visiting scientists wouldn't be able to get much done."

That kind of camaraderie comes from a shared commitment to the cause — namely, to support theoretical physicists in their work and living spaces. The admixture of staff, faculty, and families serve to create the interactive atmosphere for which the KITP is known.

"I like being involved with a place with a mission that I care about," says Sherriffs. "I've gotten to know a lot of the repeat visitors, hearing every so often that 'this is a really important experience for me,'" she says. "They're all so happy to be here. It's kind of a summer camp environment."





and Dennis Yu, KITP Computing Intern





Spotlight on the KITP





KITP 'Big Hits'

The Lasting Impact of KITP

Modules for Experiments in Stellar Astrophysics (MESA) Collaborators led by KITP research fellow Bill Paxton (and including Director Lars Bildsten and former postdoctoral scholar Matteo Cantiello) released the fourth version of their MESA software in 2017.

Professor Eliot Quataert of UC Berkeley writes that in the last three years, MESA "has solidified its position as the most important theoretical tool in modeling stars." In particular, the hydrodynamics capabilities released in the third and fourth MESA papers have made it possible to calculate everything from stellar winds to supernovae explosions and lightcurves directly with MESA. These new capabilities are being rapidly adopted by the community and I expect are going to have a huge impact in the coming years, particularly given the parallel observational discoveries on supernovae from observational time-domain surveys."

Nextflu and Nextstrain

During the 2014 "Evolution of Drug Resistance" KITP program, Richard Neher (former KITP postdoctoral scholar now at the University of Basel) and Trevor Bedford (of the Fred Hutchinson Cancer Research Center) discussed creating a cloud-based flu surveillance and prediction tool. By 2015, Nextflu was up and running.

Nextflu and its successor, Nextstrain, allow scientists to rapidly share and analyze genomic sequence data and map the evolution and geographic spread of viral strains. Ultimately, Bedford and Neher hope the tool will be used for real-time decision making by epidemiologists and public health officials. Nextstrain won the 2017 Open Science Prize, awarded for work that uses open content and data to advance biomedical research and its applications for human health.

String theory

In 1998, the KITP hosted the annual "Strings" conference in conjunction with a six-month string theory program. The meeting occurred shortly after Juan Maldacena announced the breakthrough insight of the AdS/CFT correspondence, which links certain quantum field theories and string theories.

One of the most highly-cited papers developed from the program was "4D Conformal Field Theories and Strings on Orbifolds" coauthored by Shamit Kachru and Eva Silverstein. The paper showed that the AdS/CFT correspondence could be generalized to non-supersymmetric cases, providing a new class of quantum field theories and extending its extraordinary computational power.



Where Are They Now?

KITP postdoctoral and graduate fellows make a splash worldwide

The selection of KITP Postdoctoral Scholars and Graduate Fellows is a rigorous process based on career readiness, academic excellence, and diversity. While at KITP, fellows and scholars engage actively in independent research, are mentored by faculty, participate in programs, and have the opportunity to present to the KITP community.



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Financial Highlights

Support for KITP Activities



GENERAL ENDOWMENT TOTALS

Programs, Conferences, & Support Staff

Postdoctoral Scholars

Graduate Fellows

Equipment & Materials

Family Fund



Totals are for KITP's General Endowment and do not include Endowed Chair funds, which are restricted to support faculty member research.

Why Invest in the KITP?



1. KITP tackles the big questions

What laws governed the origin of the universe? Do we live in 11 dimensions? Is matter made up of tiny vibrating strings? What is dark matter? Are quantum computers possible? How does the brain really work? Why do stars explode?

Exploring these big questions leads to breakthroughs in knowledge and inevitably changes how we see ourselves within the universe.



2. Big questions are not answered alone

The KITP leverages its international scientific advisory board and local intellectual core of faculty, postdocs and graduate fellows to attract and convene more than 1,000 scholars a year from around the world for prolonged periods of scientific inquiry. These unique interactions reveal unexpected synergies, promote the interchange of new ideas, and create powerful networks that move science forward.



3. Global science impact requires inspired investment

The Institute's internationally renowned scientific impact cannot be sustained by traditional federal funding sources alone. Beginning with Fred Kavli's inspired investment, the KITP has actively pursued diversifying its funding sources and building an endowment by engaging with private foundations and individuals.

Fortunately for the KITP, generous philanthropists like Charlie Munger are leading the way. His recent investment to fully fund the Charles T. Munger Physics Residence for KITP's visiting scholars exemplifies what is possible and inspires us to be bold in our vision for the future.

If you share in our passion for collaborative curiosity-driven science, consider making a difference by investing in sustaining the KITP's legacy of impact and excellence. With your support, we'll continue exploring new frontiers.

Please contact:

Kristi Newton, Senior Director of Development Kavli Institute for Theoretical Physics kristi@kitp.ucsb.edu · 805.893.6307





Donor Societies



Generosity to the KITP

Gifts made between December 1, 2016 - June 30, 2018

\$1,000,000 or more

Carl P. Feinberg Kavli Foundation Gordon E. and Betty L. Moore Foundation Deborah and Douglas Troxel

\$500,000 or more

The Alfred C. Munger Foundation

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Cumulative Giving to KITP as of June 30, 2018

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\$100,000 or more

Joseph and Lambertha "Tunny" Alibrandi American Committee for the Weizman Institute of Science Dr. Joseph Polchinski* and Dr. Dorothy Chun Culler Scientific Systems Corporation Bettina and Glenn Duval '80 IBM Corporation The Institute for Advanced Study Stuart and Hannelore Mabon John* and Betty J. Stephens

*Deceased



Enduring Influence





In Remembrance

Fred Kavli

Former Trustee, UCSB Foundation

Fred Kavli was a Norwegian physicist, entrepreneur, and philanthropist. He served as CEO and Chairman of Kavlico Corporation, then went on to establish The Kavli Foundation, which was created to advance science for the benefit of humanity. Over time, Fred and the Foundation made gifts to the Institute for Theoretical Physics totaling more than \$20 million. This has enabled the Institute to expand Kohn Hall and programs, and establish the Institute's general endowment. In 2002, UCSB formally honored Fred by naming the Institute after him. Fred and the Kavli Foundation have since created several dozen Kavli Institutes around the globe, inspired by the transformational impact and success of their first named Institute, the KITP.

"Science is taking us on an ever-accelerating journey into the future."

Dr. Walter Kohn

Founding Director, Institute for Theoretical Physics (now KITP) Nobel Laureate, Chemistry

Under Walter's leadership, the Institute for Theoretical Physics developed into one of the leading research centers in physics, and has since been widely emulated internationally. Walter won the Nobel Prize in Chemistry for his development of the density functional theory, which revolutionized scientists' approach to the electronic structure of atoms, molecules and solid materials in physics, chemistry, and materials science.

Together with his wife Mara Schiff Kohn, Walter established the Kohn Scholarship in Natural Sciences and Engineering. He also supported KITP and the university through loyal philanthropy. Walter was deeply engaged in matters spiritual and societal, encouraging others to take action. Kohn Hall is named after Walter and commemorates his contributions.

"Physics isn't what I do; it is what I am."

Dr. Joseph "Joe" Polchinski

Former Permanent Member of the KITP Inaugural Pat and Joe Yzurdiaga Professor of Theoretical Physics

Joe Polchinski was renowned for his discovery of D-branes and most recently for his advancement of the black hole firewall hypothesis. He was awarded the 2017 Breakthrough Prize in Fundamental Physics, a prize shared with two other physicists "for transformative advances in quantum field theory, string theory, and quantum gravity."

Joe's mentoring of graduate students and postdoctoral fellows is memorable in the field, and has allowed his impact to spread across all of theoretical physics. Together with his wife and UCSB faculty member, Dr. Dorothy Chun, Joe created the Joseph and Dorothy Polchinski Fellowship in Physics, which supports talented KITP graduate students.

"A lot of my research grew out of my work with students and postdocs. It's our role to teach and educate students."



Permanent Faculty Members pictured

Leon Balents // Boris Shraiman // Lars Bildsten // David Gross

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KITP BY THE NUMBERS

During 2017: Scientists and the public viewed nearly **10,000** KITP talks online, watching **480** hours per day.



KITP programs and conferences brought over **1,300** scientists to Kohn Hall. About ¹/₂ of them reside outside the United States.

KITP visitors used nearly **5,000** espresso pods and **4,500** pieces of chalk.





Program participants, in-house faculty and postdocs published nearly **500** papers. KITP papers were cited over **32,000** times.

Since 1994:

The **5,000** papers published by KITP participants accumulated nearly **300,000** total citations.





Front and back cover image: Yan-Fei Jiang, KITP Postdoctoral Fellow Density structures of the outer envelope for an 80 solar mass star as calculated by 3D radiation hydrodynamic simulations