UC SANTA BARBARA

Kavli Institute for Theoretical Physics

Newsletter

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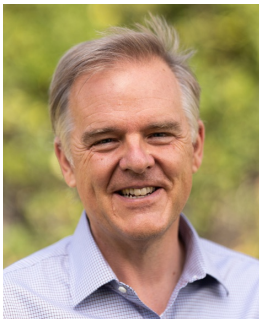
Fall 2022



MIA NIE

Lars Bildsten

I have many highlights to share this fall. The banner image is the new playground at the Munger Physics Residence. Generously funded by Alec & Claudia Webster representing the Helen and Will Webster Foundation and our good friend Charlie Munger, this provides the 5-12 year old visitors to the Residence a place to play while their parents enjoy the stunning mountain views. Thank you Alec, Claudia and Charlie!

We are now back to our full cadre of in-person visitors. There is not a spare bed at the Residence, nor an empty office in Kohn Hall. KITP's amazing staff gets all the credit for keeping pace with this return to business. We have also expanded participation by 50% by seamlessly enabling attendance via Zoom in all of our events.

Fall is the time of transition, with the departures and arrivals of KITP's postdoctoral scholars. Here are the worldly, diverse destinations of the eleven who have departed. Isabel Garcia-Garcia will be a postdoc at New York University and member at the IAS next year, and then take up a faculty position at the University of Washington in fall 2023. Xizhi Han is pursuing a career in private industry and is now a quantitative researcher at Citadel Securities. Eyal Karzbrun is now an assistant professor at the Weizmann Institute of Science in Israel. Rocio Kiman has moved to a prize postdoctoral position at Caltech. Sarah Kostinski will take up a faculty position at New York University in early 2023. Zhu-Xi Luo moved to a postdoctoral position at Harvard. Nick Noll is now a senior computational biologist at Karius. May Gade Pedersen moved to Sydney University to take up a prize research fellowship. Sean Ressler is now a postdoctoral fellow at the Canadian Institute for Theoretical Astrophysics in Toronto. Javier Roulet has moved to a prize postdoctoral position at Caltech. Josephine Suh went to IAS and Princeton for one year as a postdoc and then will take a faculty position at the Korea Advanced Institute for Science and Technology. We wish them all the best of luck in their new adventures!

Five new postdocs arrived this fall. In astrophysics, we have Logan Prust from University of Wisconsin, Milwaukee and Hang Yu from Caltech. In high energy physics, Jessica Howard came from UC Irvine, while in condensed matter physics, we have Utkarsh Agrawal from University of Massachusetts, Amherst, and Ali Lavasani from University of Maryland. All are actively engaged in our programs and our revived "Local's" gatherings, where we all learn from each other through talks and conversations.

For many years, KITP has invested in postdoctoral scholars in astrophysics who pursue large scale computation. Like an experimentalist who builds, over time, a large apparatus, these scientists have a similarly long-term focus to create the "instruments" that allow for new exploration. In the story on page 2, two KITP Postdocs (Sean Ressler and Chris White) developed three-dimensional computations of the radiation emitted from gas flowing near super-massive black holes. As you will read in the article, their efforts are enabling the interpretation of the iconic black hole "images" you have been seeing in the popular press.

One of KITP's goals is to do all we can to ensure that theoretical physicists remain impactful throughout their careers. We primarily do this through our programs, but we also attract scientists who come here to move in new directions or even write a book. On page 4, R. Shankar from Yale University shares with us his experiences here at KITP. KITP also strives to engage the local community via science outreach. On page 5, you can read about the work that KITP Postdoc Rocio Kiman did in the planetarium at the Santa Barbara Natural History Museum. She had prior experience in communicating her science, but can now add the ability to run a planetarium to her CV!

Under the leadership of KITP's Chief Administrative Officer Lisa Stewart, KITP has undertaken a new initiative aimed at supporting faculty with heavy teaching loads at minority-serving undergraduate institutions by providing them a 6-8 week visit to KITP. The research mentoring offered by these faculty encourages the transition of very talented undergraduates into graduate school, a goal we share. We are now in the first year of our three-year pilot project funded by the Heising-Simons Foundation. Please read the story on page 6 of how this came to be, and some initial stories from those Fellows who have already visited.

Every year, we work with our Scientific Advisory Board and the international physics community to create the dozen long programs that we run the subsequent year. The culmination of these efforts yields over 1300 visitors coming to the KITP annually to interact and form new collaborations. To advertise these opportunities, we ask that each program draft a brief write-up describing the program's goals and also create a Logo that assists the community in identifying the program. The visual appearances of these logos (see the back page) often lead to them having a life of their own beyond the program itself! I look forward to telling you about these exciting outcomes soon. Wishing you all the best for the fall and holiday season!

- Lars Bildsten, KITP Director

A Flicker From the Dark

Reading between the lines to model our galaxy's central black hole

KITP

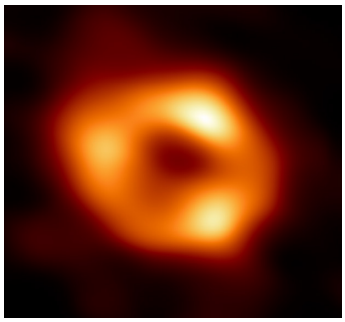
Sean Ressler

Looks can be deceiving. The light from an incandescent bulb seems steady, but it actually flickers 120 times per second. Because the brain perceives only an average of the information it receives, this flickering is blurred. The perception of constant illumination is a mere illusion.

While light cannot escape a black hole, the bright glow of rapidly orbiting gas (recall the 2019 images of M87's black hole) has its own unique flicker. In a recent paper in the Astrophysical Journal Letters, KITP Postdoc Sean Ressler, Lena Murchikova at the Institute for Advanced Study and Chris White (former KITP postdoc now at the Flatiron Institute) were able to use this subtle flickering to construct the most accurate model to date of our own galaxy's central black hole — Sagittarius A* (Sgr A*) — providing insight into properties such as its structure and motion.

There has recently, and for good reason, been a lot of excitement about the new picture of the black hole in the center of our galaxy. "But a single picture only tells part of the story," said Ressler, who was supported by a grant to KITP from the Gordon and Betty Moore Foundation.

A video would be ideal, he noted, but as of now we can construct only blurry, flickering images. Fortunately, the flickering pattern encodes a lot of information. "Here we have shown that our model of gas falling inwards from nearby stars reproduces that same pattern far better than previous models," Ressler added.



EHT COLLABORATION

First image of Sagittarius A produced by the Event Horizon Telescope (EHT)*

This is the first time that researchers have shown, in a single model, the full story of how gas travels in the center of the Milky Way — from being blown off by stars to falling into the black hole. By reading between the proverbial lines (or flickering light), the team concluded that the most likely picture of black hole feeding in the galactic center involves directly in-falling gas from large distances, rather than a slow siphoning off of orbiting material over a long period of time. "Black holes are the gatekeepers of their own secrets," stated Murchikova. "In order to better understand these mysterious objects, we are dependent on direct observation and high-resolution modeling."

The existence of black holes was predicted by Karl Schwarzschild about 100 years ago based on Albert Einstein's new theory of gravity. However, researchers are only now starting to probe them through observations.

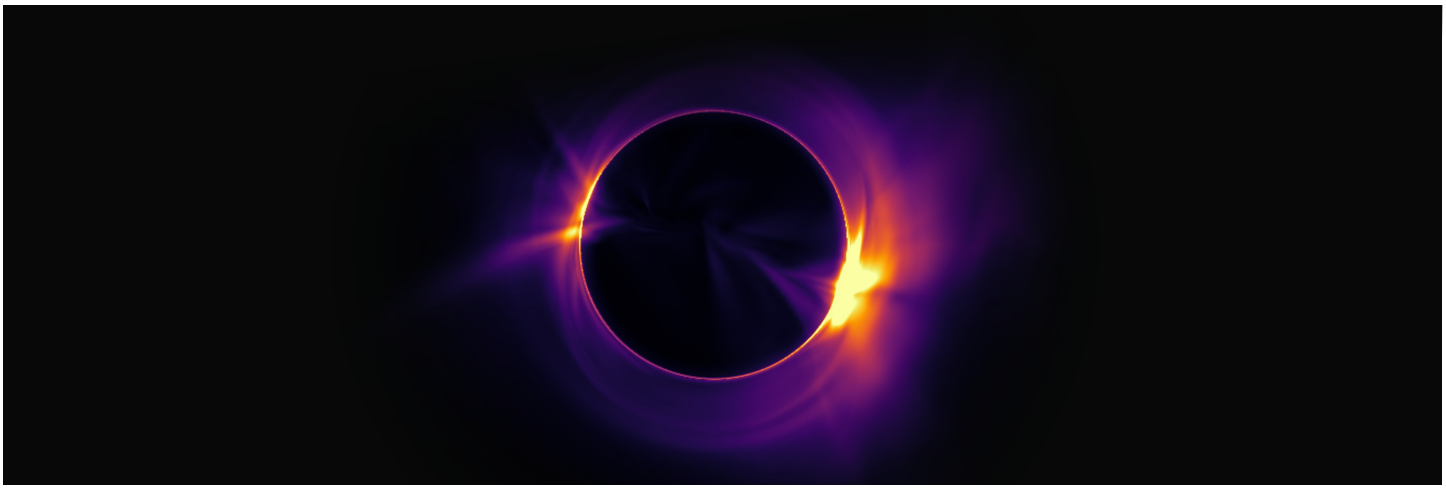
Ressler has spent years attempting to construct the most realistic simulations to date of the gas around Sgr A*. He has done this by incorporating observations of nearby stars directly into the simulations and meticulously tracking the material that they shed as they orbit the black hole. His earlier work culminated in an Astrophysical Journal Letter paper in 2020, while in October 2021 Murchikova published a paper in Astrophysical Journal Letters, introducing a method to study black hole flickering on the timescale of a few seconds, instead of few minutes. This advance enabled a more accurate quantification of Sgr A*'s properties based on its flickering. White had been working on the details of what happens to the gas near black holes — where the strong effects of general relativity are important — and how this affects the light coming to us. An Astrophysical Journal article earlier this year summarizes some of his findings.

Murchikova, White and Ressler then teamed up to compare the observed flickering pattern of Sgr A* with those predicted by their respective numerical models. "The result turned out to be very interesting," explained Murchikova. "For a long time, we thought that we could largely disregard where the gas around the black hole came from. Typical models imagine an artificial ring of gas, roughly donut shaped, at some large distance from the black hole. We found that such models produce patterns of flickering inconsistent with observations."

Ressler's stellar wind model takes a more realistic approach, in which the gas consumed by black holes is originally shed by stars near the galactic center. In this simulation, the in-falling gas reproduces the correct pattern of flickering. "The model was not built with the intent to explain this particular phenomenon. Success was by no means a guarantee," Ressler said. "So, it was very encouraging to see the model succeed so dramatically after years of work."

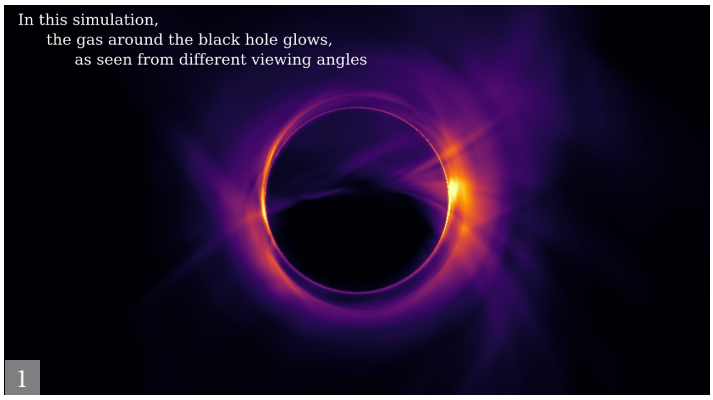
"When we study flickering, we can see changes in the amount of light emitted by the black hole second by second, making thousands of measurements over the course of a single night," explained White. "However, this does not tell us how the gas is arranged in space as a large-scale image would. By combining these two types of observations, it is possible to mitigate the limitations of each, thereby obtaining the most authentic picture."

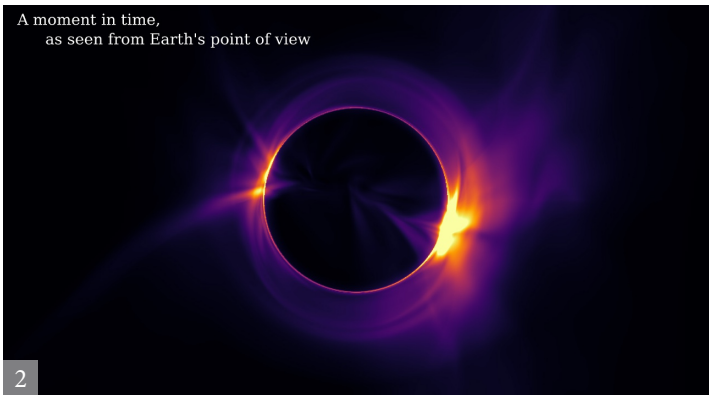
by Harrison Tasoff, Science Writer, UCSB Public Affairs

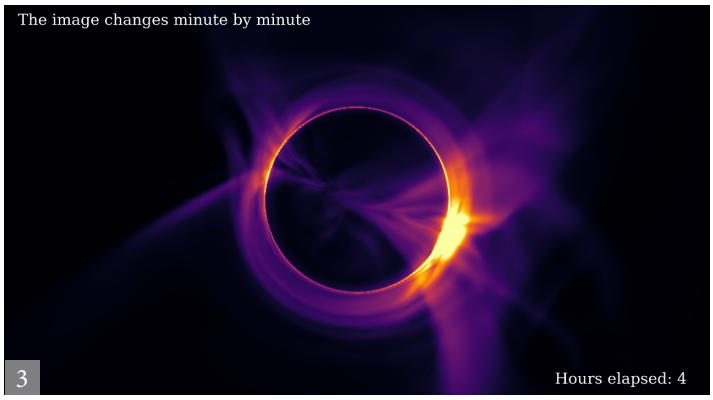


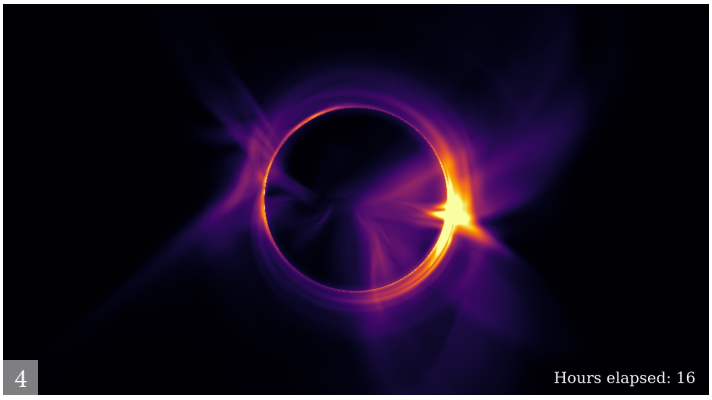
The new simulation illustrates how the flickering light around a black hole can encode information about the system

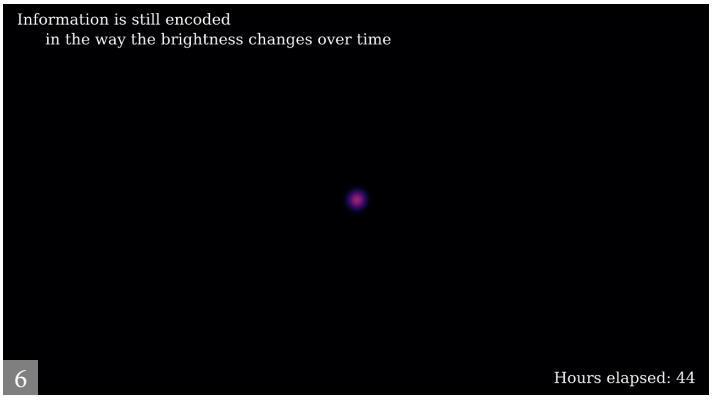
IMAGES BY SEAN RESSLER AND CHRIS WHITE



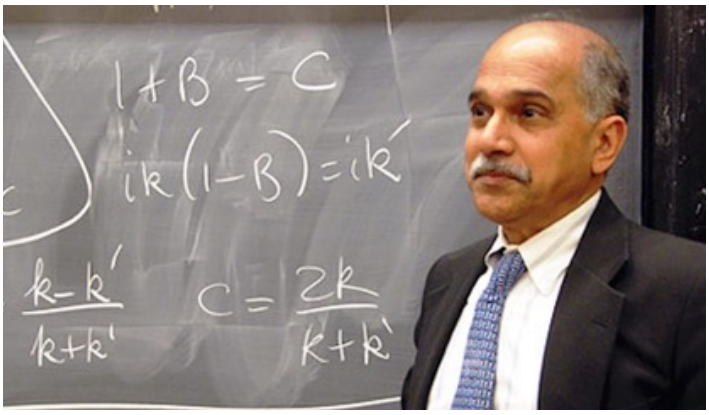








KITP and Me



R. Shankar, courtesy of Yale University

It all started in 1990 when I was attempting the transition from particle theory to condensed matter theory.

It was the best of times and the worst of times: it was an exciting time following the discovery of high T_c superconductivity, which unfortunately implied the subject was in a state of flux, with a dizzying barrage of new data and ideas. No matter how much I drank from this firehose, I could not shake the constant impression that there was a lot going on behind my back. For example, just when I had finished learning what a Fermi liquid was, I was told that Fermi liquid was so old school, and that the new thing was the non-Fermi liquid. No one seemed to know what it was, except that it wasn't a Fermi liquid. The only option (not viable) was to go on a national tour talking to the ring leaders and get up to date.

My friend Andrei Ruckenstein put me out of my misery by conjuring up a solution that allowed me to see all the experts sitting in one place: the place being KITP, which was running a workshop on this very topic in Spring 1990. He snuck me into the program and KITP secured housing for my family near campus, allowing me to focus on my work.

Now my education began in earnest, without my moving an inch. In the next six months all the major players passed through the KITP enlightening me. Unlike with usual seminars where the speakers kept the taxi waiting and had just a few hours to answer questions, the KITP speakers typically stayed on for several days or even longer if they were part of a program. This allowed the participants to pick their brains at leisure, which I did to the fullest. Since everybody who was anybody passed though the KITP, even before the end of the semester I became confident that I had assimilated all the major ideas. When I left, my conversion was complete and I never looked back. It is no exaggeration to say that without the KITP interlude I could not have made this timely and beneficial migration.

In the following years I came often to charge my batteries for stays of several weeks.

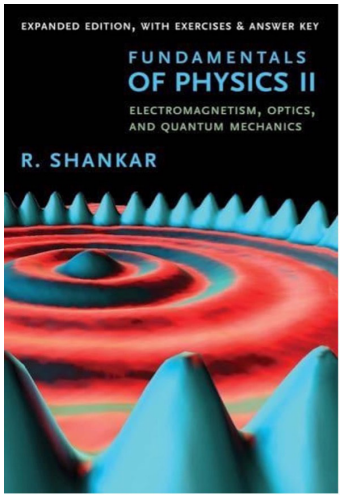
But old habits die hard and I was back in 2014 for a longer stay. Here is the context. Yale had decided to videotape a few introductory courses and put them on line for free consumption, under the heading of Open Yale Courses. My two courses on introductory physics were on this list. I was subsequently asked if I wanted to write two books based on them. I was reluctant to write any intro physics books: these were increasing in size so fast they were headed for gravitational collapse and were guaranteed to induce hernia and bankruptcy in the student. What persuaded me was the promise that Yale Press would publish them as two slim paperbacks for under $25 each.

I had a sabbatical coming up and I wanted to write the book away from New Haven, where the tentacles of Yale could grab me for committee work. Hiding in a cabin in a forest was not an option since I did not want to be in total isolation and lose touch with current physics developments.

I was able to have my cake and eat it too thanks to a Simons Professorship at KITP. I spent Fall 2014 transforming the audio and video from my lectures into Volume 2 of Fundamentals of Physics. I divided my time between writing the book and attending a lot of lectures and seminars, staying on top of my field and flirting with other fields represented by parallel workshops.

Once again KITP had come to my rescue. The book (copies of which I sent to KITP) came out with the following acknowledgement: "A large portion of the book was written at the Kavli Institute for Theoretical Physics (KITP), where I was fortunate to receive a Simons Distinguished Visiting Scholar award for Fall 2014. The KITP is supported by the National Science Foundation under Grant number NSF PHY11-25915. I am especially grateful to Professor Lars Bildsten for making this possible".

My admiration of KITP is no secret: I speak of it often to my colleagues around the globe and to the people who run it, like its current and past directors Lars Bildsten and David Gross. I have tried to repay my debt over the years by acting as cheerleader and by taking part in its governance and outreach, but that only scratches the surface.



Introductory physics book written by R. Shankar during his 2014 visit to KITP as a Simons Distinguished Visiting Scholar, courtesy of Yale University Press

KITP is a gift that keeps on giving. It renders unique services to the community, my case being one of so many.

by Professor Ramamurti Shankar, Yale University, 2014 KITP Simons Distinguished Visiting Scholar

KITP Postdoc Runs the Planetarium!

Participants in KITP's programs and fellowships are offered an array of activities that encourage working on cross-disciplinary topics with an international community of leading scientists. While group discussions around the blackboards of Kohn Hall or insightful talks are part of how physicists answer their biggest questions, KITP also places emphasis on bringing these answers to the public through outreach. Early-career scientists are particularly eager to gain professional experience in addition to their independent research, so they explore innovative ways to share their enthusiasm.

Recent KITP Postdoctoral Scholar Rocio Kiman (a postdoc at Caltech starting Sept 2022) came to KITP with plenty of outreach experience under her belt. She completed her PhD with the Brown Dwarfs in New York City (BDNYC), a research group based at the American Museum of Natural History in New York City, where she was a member of the Astronomy department. There, she participated in educational events for youth and families while familiarizing herself with working in a museum setting.

When she arrived at KITP in September 2021, Kiman was interested in pursuing outreach here, she just was not expecting it would be with another museum. Serendipitously, though, a fitting opportunity presented itself when she visited the Santa Barbara Museum of Natural History. As an astrophysicist studying M dwarfs (stars that are about 10-20% the mass of the Sun), Kiman was attracted to the astronomy section. When she reached out about volunteering, she received an overwhelming "yes and yes, we'd love to have you," from Krissie Cook, the museum's Astronomy Programs Specialist. Cook was thrilled to provide programming from a native speaker of Spanish—and science.

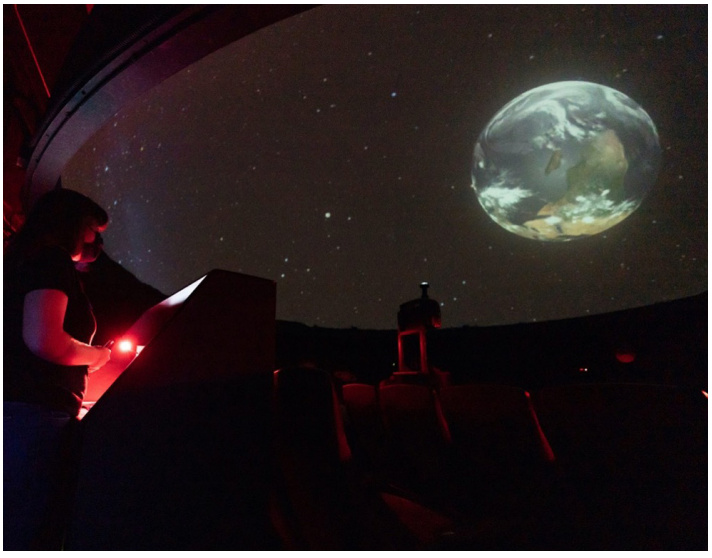
First, Kiman gave a talk about the Moon to the Girl Scouts of California's Central Coast's Astronomy Club before the lunar eclipse in spring 2022. Cook shared how the group was excited by "not just Kiman's field of study, but also the way she related to them. It was really warming to see all these young girls inspired by this other woman in science who could inspire them to move on to a STEM career themselves." Evidently, Kiman's talk with the Girl Scouts was a success, and she was later invited to discuss the James Webb Space Telescope in a YouTube video created by the museum.

In July 2022, Kiman took on the challenge of facilitating shows about the Solar System at the museum's Gladwin Planetarium—her first time using a planetarium in her career. It took plenty of practice before she was ready to present to the public, but she was excited to learn how to use such a dynamic teaching tool. Kiman emphasizes the planetarium's unique ability to transform the learning experience for visitors. "Instead of imagining what a star or a planet looks like, I can take the public to it, and show them." She took a creative approach towards her development as a science communicator, fostered by the unique and supportive environment KITP provides for postdoctoral scholars.

Other than gaining new pedagogical skills, Kiman was also meeting a community need by providing the only live Spanish-language show offered over the summer. "I'm Argentinian, so it is especially rewarding to use my first language to talk about science to the public and reach that big Spanish speaking community in Santa Barbara, and hopefully get them excited about science" she proudly explains. The role, as well as Cook's belief that "all audiences are capable of learning," aligned well with Kiman's passion for making science more accessible. Kiman is careful to communicate scientific ideas "in a way that someone regular, from the public, can understand." It is essential for Kiman to build a "connection" between the topic and the listener. She believes that without building this bridge of understanding, one could be discouraged by science instead of curious about it.

One way she practices this is by presenting "open problems," or the issues that scientists still don't entirely understand. By exposing others to the unanswered questions, she shows them that scientific discovery "is a path they can follow if they want to," and "it's not that far away from them." Ultimately, she is determined to exemplify how "science is something extremely interesting and not just this remote thing that only a selected group of very smart individuals do. That's the image that we have of science, and it's not like that anymore." Outreach like Rocio's ensures that people of all ages, backgrounds, and interests can celebrate the wonders of science without barriers.

by Demi Cain, KITP Development Coordinator



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Rocio Kiman presenting in the Santa Barbara Museum of Natural History's Gladwin Planetarium

Enhancing Research

The KITP launches a fellowship for physics faculty at minority-serving institutions

Top (left to right) Louise Edwards, Igor Bondarev and Alexander Klotz and Bottom (left to right): Joel Walker, and Samaresh Guchhait

Many characterize science as disinterested, a dispassionate search for the truth of nature and unconcerned with politics and justice. The folks at KITP, however, believe science is most fruitful when scientists collaborate, share their experiences and join together as a community. They see science as a human endeavor — and they work tirelessly to support it in all ways possible.

Case in point: in Fall 2022 KITP launched a new fellowship that aims to address the underrepresentation of minorities in physics, especially theoretical physics. "This program specifically targets physics and astronomy faculty at teaching-intensive U.S. colleges and universities designated as minority-serving institutions," said KITP's Chief Administrative Officer Lisa Stewart.

"Good ideas don't flow in one direction," she added. "As with any of the over 1,000 visiting scientists to KITP each year, we expect fellows to bring their own research ideas to contribute to the conversations, and hopefully they'll find new ones here that stimulate their own research as well."

Funded by the Heising-Simons Foundation for a three-year period, this new program covers fellows' travel and accommodations for six to eight weeks, in addition to a stipend. This stipend should alleviate financial worries an applicant may have about needing to take on additional teaching obligations to make up for the time they'll be away.

"Many students at non-R1, minority-serving institutions would like to participate in research," said KITP Director Lars Bildsten. "Research experience can help them gauge their interest in pursuing a career in a STEM field. The KITP Fellows Program supports physics and astronomy faculty from these schools who are eager to expand opportunities for undergraduate research.

"We hope that, in addition to boosting faculty research, this program also increases the retention within STEM disciplines of students from underrepresented minorities," Bildsten added. The first cohort consists of five KITP fellows (pictured above):

- Louise Edwards — Cal Poly San Louis Obispo
- Igor Bondarev — North Carolina Central University
- Alexander Klotz — Cal State University Long Beach
- Joel Walker — Sam Houston State University
- Samaresh Guchhait — Howard University

Each fellow chose a time to visit based on KITP's schedule of

programs and conferences, or an opportunity to interact with others at KITP and at UC Santa Barbara. The experience will enable faculty with higher teaching loads to devote time to their research and collaborate with UCSB and KITP faculty, visitors and postdocs.

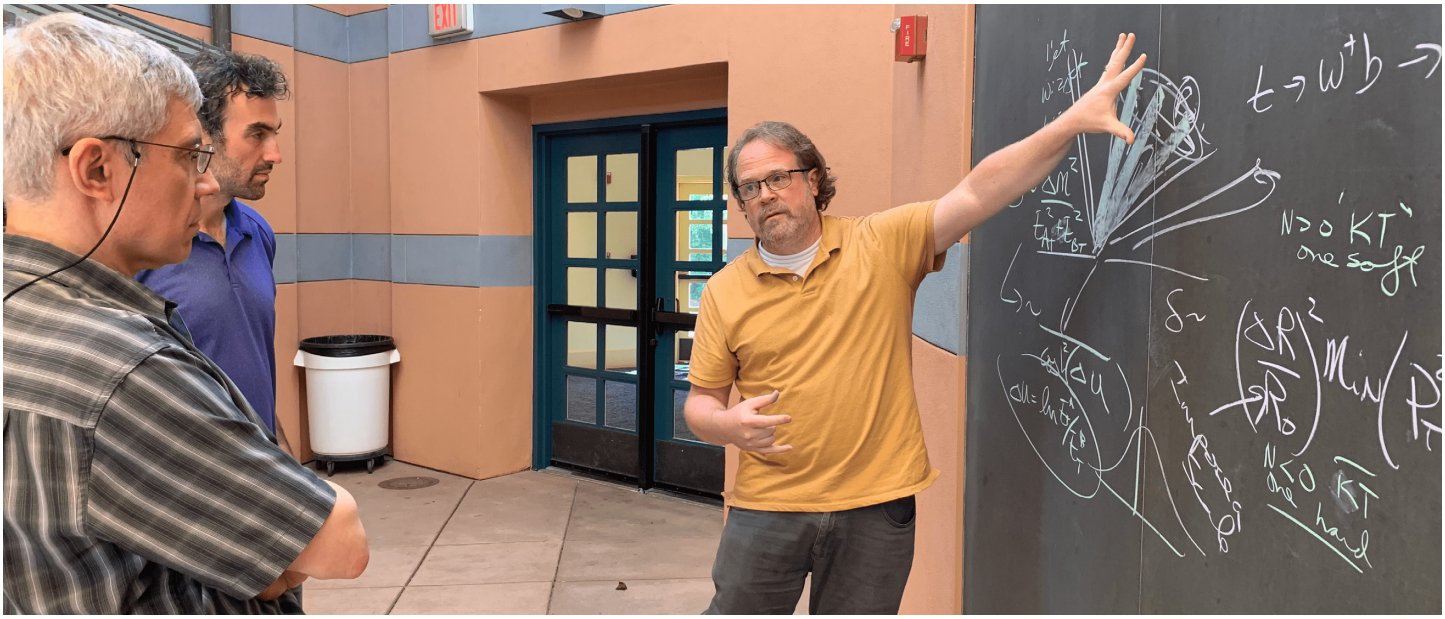
The new program builds upon the success of the KITP Scholars Program, established in 1998. Similar to the fellows program, the scholars program supports visiting physics researchers who are faculty at teaching-intensive U.S. colleges, although they are not required to be minority-serving institutions. Scholars are invited for three two-week stays over the course of three years.

Current fellow Joel Walker has visited the institute before as a KITP scholar. "Faculty at smaller and teaching-intensive universities can easily lose contact with the larger mission and progress of theoretical physics," said the particle physicist. "The scholars program helped me integrate with the community and better understand the scope of current activities and priorities."

For example, Stewart attended the National Society of Black Physicists (NSBP) conference in 2019, where she encountered incoming President Stephon Alexander. "As I listened to Stephon's aspirations for NSBP, in a room filled with hundreds of Black physicists, my mind was racing with possibilities for connections with KITP."

Not long after this, Bildsten, Alexander and Stewart began to co-organize an event for the summer of 2020, an event that ultimately was cancelled due to the COVID pandemic. Those planning efforts pivoted into the launch of a different, virtual seminar series as KITP began co-hosting the NSBP Innovate Seminar Series, a new forum for NSBP members to share their research ideas and projects with a wide audience.

But Bildsten, Stewart and the rest of KITP's team wanted to do more. So, current NSBP president Hakeem Oluseyi recommended leveraging the institute's core strengths. "Your focus is on faculty,"



Bondarev, Klotz and Walker discuss topics of a mathematical nature in the Gurley courtyard at Kohn Hall

Walker credited the experience with helping him make more productive choices in research projects and contributing to his subsequent success with National Science Foundation grants. "It made me feel included and active, building confidence and enthusiasm that gets recommunicated in the classroom," he continued. "This likewise increases the chance that our students — many of whom are first generation or from groups historically underrepresented in physics — will pursue graduate education and a career of their own in the field."

The KITP Fellows Program is the result of several years of collaboration between the institute and the Heising-Simons Foundation. "The foundation encouraged us to explore new ways for KITP to engage the physics community that might have broader impacts than our current programs," Bildsten recalled. "This led to many discussions that Lisa and I had with different physics organizations that focus on ensuring participation of underrepresented groups in physics."

Stewart recalled him saying. "Why not make a program that focuses on faculty development?"

With NSBP's facilitation, Alexander, Stewart and Bildsten connected with physics departments at historically Black colleges and universities in conversations to refine the idea. They also met with the leadership of the National Society of Hispanic Physicists. The Heising-Simons Foundation has pledged an initial three years of funding. For its part, KITP is committed to making this a permanent fellowship.

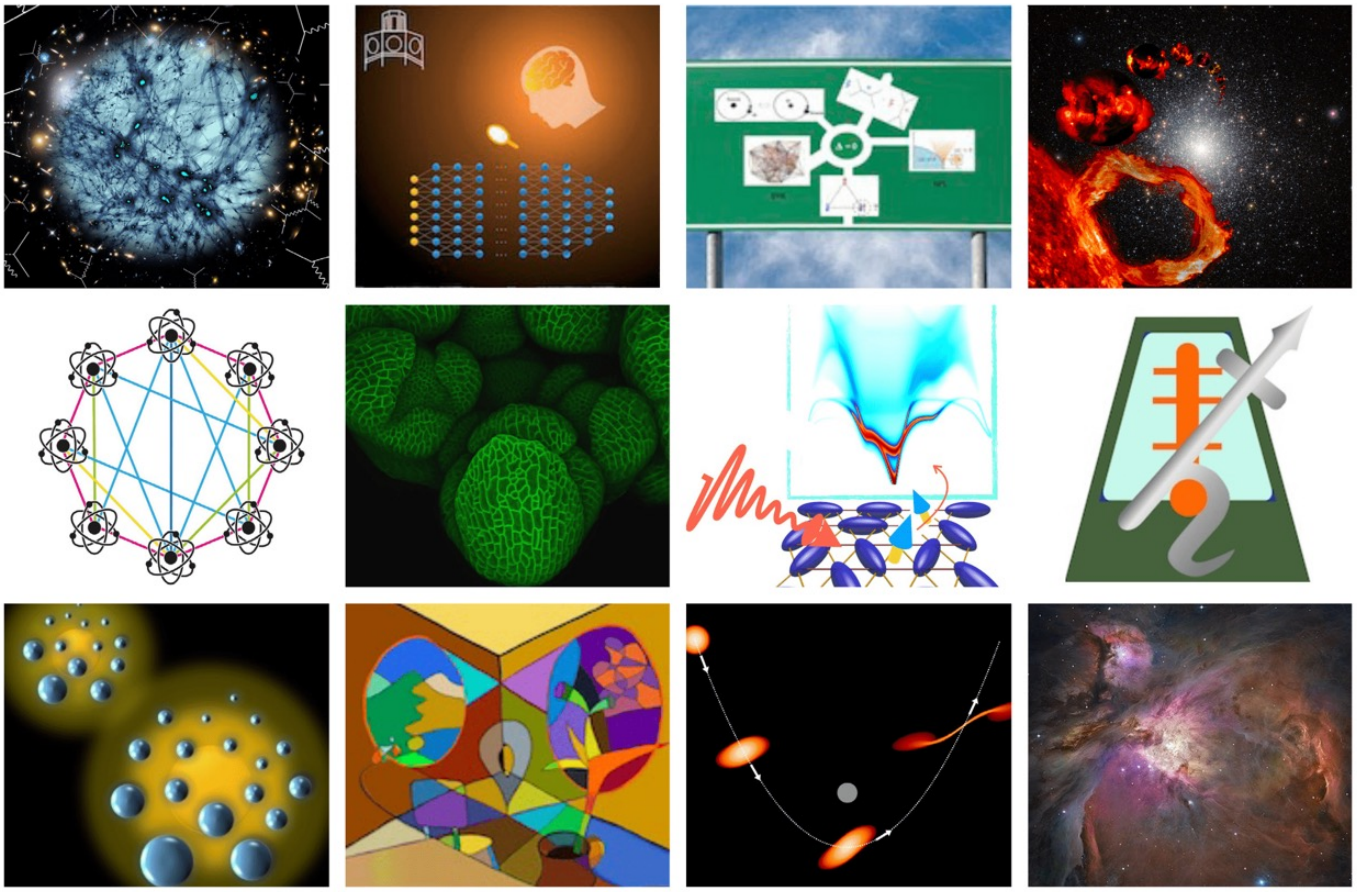
"I'm eager to see what impact we can have with our first three years of exploration," Bildsten said.

by Harrison Tasoff, Science Writer, UCSB Public Affairs

Looking Ahead at KITP

Upcoming scientific programs for 2023-2024

KITP's Advisory Board and faculty worked with scientists from around the world to develop 12 programs for the next academic year. Collectively, these programs will convene more than 800 diverse scientists at KITP to explore quantum magnets, string theory, deep learning and neuroscience, astrophysical turbulence, and more.



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