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Kavli Institute for Theoretical Physics

Newsletter

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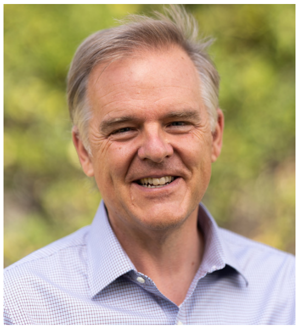


Lars Bildsten

The banner image is a rendering of KITP House, our newest project aimed at enhancing collaborative science for the next century by providing housing for our postdoctoral scholars, graduate fellows and long-term sabbatical visitors. All of these KITP scholars are challenged to find suitable housing in the local market and are scattered throughout Goleta and Santa Barbara. Following the successful construction and operation of the Charles T. Munger Physics Residence—our purpose-built facility funded by Charles T. Munger to house KITP's visiting scholars—a consortium of donors has funded the new property purchase and will fund and undertake the design, construction and furnishing of this new building.

Already, over $7 million was gifted to acquire a vacant, 1.2-acre parcel for the project. The property sits at El Colegio Road and Camino Pescadero, directly across the street from the Munger Physics Residence. KITP House will enable nearly continuous collaboration between visiting and long-term KITP scholars. The new facility will feature high-quality design and construction as well as landscaped outdoor space for private use and social activities for those who live there. ZGF Architect's Los Angeles office is undertaking the design work, and I have been able to bring back the project manager from the Munger Residence construction, Ray Aronson.

We are off to a great start! We have already attended three UCSB Design Review Committee meetings and received campus approval on June 24, 2025 to proceed to the next phase. I will continue to update you as we progress through the design and construction, which we expect to begin in early 2026 for a projected opening in late 2027.

Given the news of the KITP House, it's very fitting that we announce the matching challenge from an anonymous donor to honor Glen H. Mitchel, Jr. Glen introduced me to Charlie Munger in July 2012 and was an integral part of ensuring that the building's construction met the highest standard. To honor Glen's contribution, an anonymous donor has offered a $1,000,000 matching challenge to endow support for the professional development of KITP Postdoctoral Scholars. As explained in that article, this fund will ensure that these early-career scientists have the travel and research resources they need to succeed. Please consider making a contribution.

Many spontaneous events occur at the KITP. The article starting on page 3 tells the remarkable story of a visitor, Professor Jonathan Feng (UC Irvine), who gave a talk at a KITP conference only to discover that a program manager from the Heising-Simons Foundation, Jochen Marschall, was in the audience and found his idea so inspirational that he offered funding support. The resulting experiment is now underway, and first results are out. Although Jonathan is a theorist, he saw an experimental opportunity and made the most of it!

KITP is viewed by many as one of the prime centers for theoretical physics in the world. This is due to both our programs that bring over 1,000 visitors to the institute, as well as the faculty, postdocs and graduate fellows that are the intellectual basis of all we do. France's national science agency, CNRS (Centre National de la Recherche Scientifique, or National Science Research Center), approached KITP about establishing an international research lab in Kohn Hall that would support 3-6 long-term scientific visitors from French institutions. Led by Lucile Savary (CNRS/ENS Lyon) and Boris Shraiman (KITP Permanent Member), this endeavor has been underway for about a year and has already led to new science that demonstrates its significance, as described on page 6.

Our final article was written by a KITP program participant, Professor Paul Duffell (Purdue), explaining one specific value of bringing scientists together for long periods: the opportunity to truly compare results. The venue was the science problem of the interaction between a stellar binary and the disk of material surrounding it at birth. Many separate research groups had calculated the resulting interactions but found disparate results. As Paul describes, only by having all of these scientists together can you truly resolve the differences and agree on a set of standard test problems and their outcomes. Such an exercise was famously carried out in 1999, when 13 different groups compared their computations of clusters of galaxies. That paper has been cited over 400 times and continues to be a landmark contribution. We hope that the effort described by Paul is equally successful.

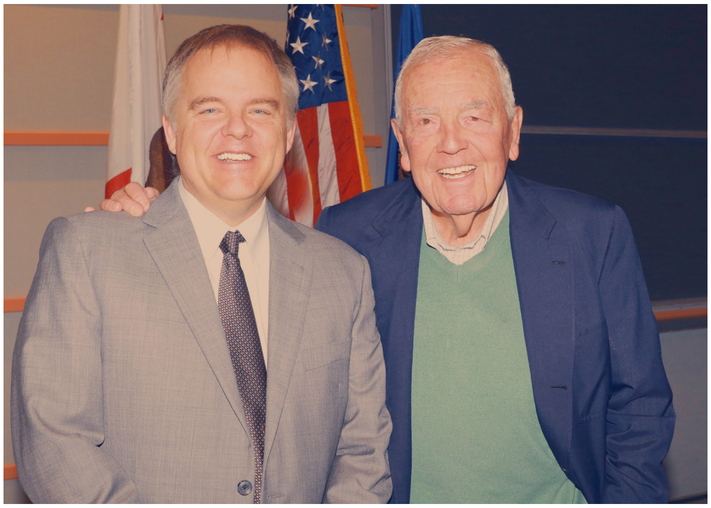
In closing, we continue to forge ahead here at KITP and have announced our programs for the 2026-2027 academic year. We continue to see excellent science and opportunities all around us and look forward to finding new scientific directions. Thanks so much for all of your support and engagement here at KITP!

- Lars Bildsten, KITP Director

A New Resource for KITP Postdoctoral Scholars

Establishing a permanent legacy and named endowment in honor of Glen H. Mitchel, Jr.

The institute has recently received a generous $1,000,000 matching gift commitment from an anonymous, long-time friend of Glen Henry Mitchel, Jr., to establish the Mitchel Postdoctoral Scholars Career Development Fund. KITP is working to build this endowment as a meaningful tribute to Glen's legacy. This initiative has already galvanized many of Glen's friends and family members to contribute to this effort, and we are well on our way toward reaching our $2,000,000 total funding goal.



Glen H. Mitchel, Jr. with Lars Bildsten

Glen Henry Mitchel, Jr. was a lifelong Friend of KITP who became passionately engaged with the mission of the institute through participating in KITP's outreach programming. Glen was instrumental in realizing the Charles T. Munger Physics Residence by introducing his good friend Charlie Munger to KITP Director Lars Bildsten. Moreover, he provided incredible leadership, thoughtful oversight and many hours of tireless work to achieve the vision of a purpose-built Residence for KITP's visiting scientists and their families.

KITP Director Lars Bildsten, who became quite close with Glen, said "Glen was famous for his inspections on the job site. He would lace up his boots, drive over and just show up—surprise! This would cause a shock wave on the job site, as he had such an eagle-eye for seeing what was happening and, in a very gentlemanly way, pointing it out. Over time, all members of the construction team came to embrace his arrivals, rising to the occasion to proudly show him the work they had done. By graciously sharing his passion for an excellent product that would last for the ages, he inspired all workers on site to do better, as they knew that their work would be recognized and appreciated by Glen." Throughout his lifetime, Glen also generously supported KITP Postdoctoral Scholars with his own annual contributions.

Hank Mitchel, Glen's oldest son, shared on behalf of himself and his siblings, "we are incredibly proud of our father, Glen Henry Mitchel, Jr., and of the good work he, his good friend Charlie Munger, and KITP have accomplished together."

The institute's top funding priority for some time has been to build an endowment to fully fund and support the research and career development of KITP Postdoctoral Scholars. Our postdocs come from a diverse range of backgrounds to pursue groundbreaking research and to foster collaborative networks. The KITP Postdoctoral Scholars Program has produced more than 250 of the world's leading early-career physicists over the past 45 years. Many have gone on to lead physics departments and institutes around the world, and some have contributed to the creation of new fields of study during their time at KITP. The connections they form while at KITP impact the institutions they join, collaborations they initiate, students they mentor, and industries they influence. The skills that KITP Postdoctoral Scholars gain—learning how to ask important questions, look for patterns, take risks and collaborate within and outside of their fields of interest—are vital for their scientific careers.

The Mitchel Postdoctoral Scholars Career Development Endowed Fund will support KITP Postdoctoral Scholars by helping them purchase computing equipment for their research, host their scientific colleagues for research-related visits to KITP, and cover the costs of participating in academic conferences where they present their work and spark new collaborations.

We invite you to join us in this effort! KITP will celebrate and share the news of all generous gifts towards this matching initiative within our scientific and support communities. In recognition of investments of $100,000 or more, we will proudly list donors' names on our leadership donor wall at Kohn Hall and in KITP donor rosters. All gift commitments, regardless of size, in support of the KITP Mitchel Postdoctoral Scholars Career Development Endowed Fund will be matched and will have a lasting impact on the future of the institute and science across the world.

by Kristi Newton
Senior Director of Development, KITP

A Shot in the Dark

Researching one of the most puzzling unsolved problems in physics

Photos of FASER installation, a visit by Mark Heising and Jim Simons, and experiments, courtesy of CERN.
Credit: (top left & bottom right) Maximilien Brice and Julien Ordan, (top right) Jacques Herve Fichet, (bottom left) Maximilien Brice

In early 2017, theoretical physicist Jonathan Feng was working with postdoctoral scholars in his group at the University of California, Irvine, when he came to a sudden realization: the largest physics experiment in the world had a blind spot. The Large Hadron Collider (LHC) in Geneva, Switzerland, is designed to shoot beams of protons through a 27-kilometer circular tunnel buried 100 meters underground. When they smash into each other at high speeds, they create a shower of smaller particles that are measured by detectors the size of an apartment building. The collider was created to discover the secrets of the universe by finding particles that had never been seen before. In 2012, it hit pay dirt with the discovery of the Higgs boson, a super tiny particle that theorists had claimed existed for decades, but never proven.

Standing at his blackboard, however, Feng realized that the beams of protons slamming into each other at collision points might be producing even smaller particles with very weak interactions. In the energy of the collision, they wouldn't veer off at an angle within the instrumented parts of the experiments where they could be detected, but keep going forward, presumably passing through the bedrock wall of the collider and disappearing. The problem was, there was no detector there.

"The LHC, which has been the 800-pound gorilla in our field for decades now was missing this opportunity," Feng says. "All these new particles created at this multi-billion-dollar collider were just streaming down the beam pipe and being missed."

In a flash of inspiration, one of his postdocs Googled "LHC map" and came up with a schematic of the underground complex at CERN (Conseil Européen pour la Recherche Nucléaire, or European Council for Nuclear Research), which showed that detecting such particles might be possible. "We found there was an existing tunnel that just happened to be kind of in the right spot," Feng says. Excitedly, they wrote up a paper spelling out their idea, thinking someone would pick up on it. After all, as a theoretical physicist, it was Feng's job to propose theories, not carry out experiments to prove them. As the months went by without any kind of response, however, Feng realized that CERN's experimental physicists were busy with their own projects. If he was going to see his idea come to fruition, he'd need to get it built himself. "That," Feng says, "is how I became an experimentalist."

MYSTERY SEARCH

Since the early 1970s, physicists have believed in a Standard Model of the universe, which posits that all matter consists of tiny atoms, made up of smaller particles such as protons and neutrons, which in turn are made up of even smaller particles such as quarks. As useful as the model has been to explain the universe, it has a major flaw: it only predicts about 5% of the mass we can observe.

"The galaxies and stars are rotating too fast to be bound by the visible mass," Feng explains. "It implies there is some new as-yet-unknown particles in nature."

The LHC was created in 2008 to not only identify the last particles predicted by the Standard Model, but also to search for so-called dark matter—these previously undetected particles that could account for some of the universe's mysterious missing mass. Feng has been a proponent of a theory known as supersymmetry, which proposes that for every particle in the Standard Model, there is a 'superpartner' with similar properties but a different spin, and some of these may be candidates for dark matter. In more than a decade of smashing protons, however, the LHC has been unable to find any evidence of such particles. That has led Feng and others towards another theory, that dark matter isn't made up of these large particles at all, but rather, much smaller particles with weaker interactions such as dark photons—the kind of particles that would disappear down the LHC's blind spot.

Discovering them could help scientists finally explain the nature of the universe and how galaxies are formed.

"The search for dark matter is one of the two or three biggest problems in physics," says Jochen Marschall, director of the Science program at the Heising-Simons Foundation. "It's a Nobel Prize–winning discovery for whoever finds it and confirms it." For that reason, Marschall was immediately intrigued when he first heard about Feng's proposal, dubbed the FASER (Forward Search) experiment. It seemed to him to represent a completely untapped opportunity for physicists to finally catch a glimpse of the elusive dark matter that binds the universe together. Moreover, Feng's proposed detector also had the potential to study other known particles such as neutrinos that would also be carried down the beam line to the LHC's blind spot. Creating FASER and navigating CERN's bureaucracy to install it, however, would not be an easy task—and the clock was ticking.

A RACE AGAINST TIME

Feng's first opportunity to get FASER off the ground was at a prestigious conference of physicists, where CERN's senior leadership was in attendance. When he presented his idea, they were skeptical, but intrigued enough to at least refer him to a physicist who could check out the mysterious tunnel he'd seen on the online map. He sent back photos showing the tunnel could be cleaned out to accommodate a detector along the lines that Feng had proposed.

Better yet, he referred Feng to other scientists at CERN, eventually leading him to Jamie Boyd, an experimental particle physicist from the UK, who had worked at ATLAS, one of the collider's two major experiments. More recently, he had served as overall coordinator at the center, making him familiar with the ins and outs of CERN's bureaucracy. Feng's idea sounded like just the kind of promising new project he'd like to get involved in—but he had his reservations. "There are many projects like this, which sound exciting, but when you dig into the details, they are difficult to implement," Boyd said. "In particular, funding is always difficult."

At least Feng's project wouldn't require CERN to drill a new tunnel 100 meters underground. It would, however, require some excavation along the existing tunnel floor to bring it in line with the beam, and there was no way that could be done while the LHC was running. The collider was scheduled to be shut down for two years of maintenance starting in 2019, however.

If FASER could be installed then, the timing would work. That presented Feng with a frustrating chicken-and-egg dilemma. In order to convince CERN he could install FASER quickly, he needed to show he had the funding to do it; but in order to get funding, he had to have some guarantee the project would be installed. Under the most optimistic timeline, the National Science Foundation would take more than a year to approve funding—meaning they'd miss their window. The next opportunity wouldn't be for another five years.

That's when Heising-Simons' Marschall heard about the project, when Feng presented it at KITP's conference "New Probes for Physics Beyond the Standard Model" in April 2018.

Heising-Simons had a long track record of funding innovative projects in science. Mark Heising got his master's in electrical engineering and computer science, worked as a chip designer before going into finance, and never stopped believing in the capacity of science for making transformative discoveries. The Foundation made its first grants in science and climate change in 2008, and it has since provided over $250 million for scientific research.

Always on the lookout for innovative new ideas, Marschall had gone to KITP to find new projects where the Foundation could make a difference.

"We can't compete with the National Science Foundation, and we don't really want to be a small part of a big thing," Marschall says. "We look for things at a scale where we can have a big impact."

What excited him about Feng's proposal was its simplicity—compared to the giant cylindrical detector of ATLAS, which is 44 meters long by 25 meters high, FASER's detector would only be about 5 meters by 1 meter, about the size of a large canoe, and most of it could be built with existing parts at CERN. Crucially, however, Feng's team would have to build powerful magnets from scratch, which would take some time.

Marschall approached Feng after his talk and after speaking for over an hour, invited him to send a proposal. Feng made it clear that CERN hadn't yet approved the project, but Heising-Simons was willing to take the chance. Within just a few months, the Foundation approved $1 million for the project, with the first check cut by November—an incredibly fast timeline for a funder to approve a grant to a scientific project.

What's more, Marschall also reached out to the Simons Foundation, a sister foundation focusing on science with which it sometimes collaborates on projects.

"The fact that it was a very original experiment with a relatively low cost but potentially high reward from discoveries, made us really enthusiastic about it," says Gregory Gabadazde, senior vice president for physics at the foundation and dean for arts and sciences at New York University. The Simons Foundation committed another $1 million to the project.

With those funds, Feng's team could not only start building the large cylindrical magnets, but also demonstrate to CERN that it was serious.

"This is a really steep change from how things usually work. Suddenly, it became something that could really happen," says Boyd, who was able to convince the organization to green light the project. FASER used 96 tracking detector modules built for ATLAS along with spare calorimeter modules from another big experiment, LHCb, to put together to the device, which was ready to be installed on time.

Mark Heising and Jim Simons visit FASER, courtesy of CERN. Credit: Jacques Herve Fichet

FORWARD TO THE FUTURE

As soon as FASER started taking measurements in 2021, it began producing results. While it has not succeeded yet in discovering dark matter, it has been able to further narrow the scope of where it potentially exists.

"We've put limits on dark photons and axionlike particles," Feng explains, describing a plane with a range of masses and coupling strengths on its axes. "We've been able to rule out a healthy chunk of that parameter space, to focus everyone's attention on what's left."

In other words, FASER has further shown where dark matter isn't—a vital step in determining where it *is*.

Just as exciting, however, FASER's other mission of identifying neutrinos has been wildly successful. Neutrinos are incredibly small subatomic particles that are among the most abundant objects in the universe, but very difficult to detect due to their small mass and weak interactions. While scientists have observed neutrinos from cosmic radiation, they've never seen them in a collider before. In its first run of data, FASER found 153, most in an energy range never seen before, allowing for potentially new discoveries about their properties. Those neutrinos were all muon neutrinos. A few months later, FASER also discovered the first electron neutrinos produced at a particle collider, and the collaboration expects to discover the first tau neutrinos once it has time to analyze the data that has already been recorded.

Neutrinos can also be used as "messengers" to better explain properties of quarks and other particles within protons. "That's super-important, because not only are protons part of everyday life, but they're central for all kinds of scientific studies," Feng says. "This will help us better understand what protons are made of, and pin down answers to all sorts of other questions."

So dramatic were all these findings, that the FASER team proposed that CERN dig out an entirely new facility dubbed the Forward Physics Facility with a separate entrance from the surface and room for several larger and more powerful detectors for both dark matter and neutrinos—with capacity to discover as many as 1,000 particles in a single day.

Another project, proposed by Feng's UC Irvine colleague Jianming Bian would use a different technology to detect particles. Instead of an emulsion film that has to be changed out and developed periodically to avoid overexposure, the device, called FLArE (Forward Liquid Argon Experiment), would use a chamber of liquid argon that would not only be able to measure many more interactions, but also refresh with each observation in real time. "By analyzing the timing and positions of signal electrons that reach several layers of readout planes oriented in different directions, we can create a high-resolution 3-D image of an interaction," says Bian, an Associate Professor of Physics & Astronomy. Once again, Heising-Simons has provided the initial funding, granting Bian $550,000 to hire postdocs and subcontract the technical designs.

The Forward Physics Facility is still under review by CERN, but given the success of the relatively small FASER project and the well-developed plans for the new detectors, approval is promising.

"This time it's more difficult, because it's a lot more expensive," says Boyd, pegging the price tag upwards of $30 million. "It's not guaranteed, but it's really helped that we've been getting such nice results out of FASER, so it's motivating us to push for it."

If the facility does get built, then it may represent the best chance physicists have to finally solve the mystery of dark matter, as well as other untold secrets of the universe—not to mention, an expectation beyond Feng's dreams when he stood before his blackboard seven years ago with a vision. "It's been a wild ride," he admits. "And honestly, the thrill of my scientific lifetime."

by Michael Blanding for Heising-Simons Foundation

FACTS

An international collaboration to advance condensed matter physics

(Top left to right): Jiaxin Zhang, Thibaut Divoux, Lucile Savary, Boris Shraiman, Ren-Bo Wang
(Bottom left to right): Antonin Roge, Peter Holdsworth, Leon Balents, Mark Bowick

Last year, KITP launched a new partnership with the CNRS, the French "National Science Research Center," in the form of a new CNRS International Research Lab (IRL), called the French American Center for Theoretical Science (FACTS). It is based in Kohn Hall and entirely embedded in the scientific life of KITP.

The CNRS is the largest scientific institution in France and employs more than 25,000 researchers in all fields of science and humanities across the country. KITP is a familiar place to French physicists, with many coming every year to its programs for extended periods of time. Many of KITP's faculty members have also had long-term collaborations with CNRS researchers, some who were postdoctoral researchers or graduate students at KITP or UCSB, in a wide variety of fields. These long-standing ties between French scientists and KITP and the commitment of scientists to work at Kohn Hall for at least six months—reflective of the institute's mission since its inception to encourage collaboration through long stays—made the center's location at KITP an obvious choice.

FACTS presently covers the fields of hard and soft/biological condensed matter theoretical physics. It is led by Lucile Savary, a CNRS researcher in hard condensed matter physics, and KITP Permanent Member Boris Shraiman. Additionally, the initiative can host up to three long-term senior members of the French scientific community who actively participate in KITP's scientific programming and activities. At the time of writing, two scientists from Lyon, Thibaut Divoux and Peter Holdsworth, are at FACTS, as well as postdocs Ren-Bo Wang, Jiaxin Zhang and student Antonin Roge. Moreover, KITP Permanent Member Leon Balents and KITP Deputy Director Mark Bowick have also joined the center as local scientists. Applicants from France are selected once or twice per year by a scientific steering committee of scientists from MIT, Frankfurt University, the Collège de France, Flatiron Institute and the CEA (the French "Alternative Energy Commission") who were selected for their expertise in the fields studied at FACTS.

Exciting new research is currently taking place at FACTS. Thibaut Divoux is working on rationalizing existing fractional rheological models by proposing a physical interpretation rooted in the study of superposition principles such as time-shear and time-aging in viscoelastic materials. This work helps establish a more physically grounded framework for interpreting the rheology of soft amorphous materials such as colloidal gels or soft glasses, and a student, Jacques Blin, will soon join him for a short visit.

Peter Holdsworth and Lucile Savary, together with visiting student Antonin Roge, are investigating new quantum states of magnets. With the growth of new "larger-spin" materials in experimental labs across the world, it is becoming crucial to develop theory to understand what new phases, qualitatively different from those already known, should appear in such materials.

Lucile Savary and her postdocs Jiaxin Zhang and Ren-Bo Wang are collaborating with KITP Permanent Member Leon Balents to try to better understand the role of quantum geometry in materials. The field of topology truly emerged in condensed matter in the last 3-4 decades, with many important workshops on this topic run at KITP. Only in the last few years have more subtle aspects of quantum geometry been discovered, in part via the recent breakthroughs in flat band materials growth. With this work, all members of FACTS continue pushing the boundaries of their fields.

FACTS Director and CNRS researcher Lucile Savary is originally from France but has spent a large fraction of her life in the United States on both the East and West Coasts and is very familiar with KITP and UCSB. She received her PhD from UCSB in 2014 and since then has spent several long-term visits at KITP for research programs, two of which she co-organized: *Correlated Systems with Multicomponent Local Hilbert Spaces* in 2020 and *A New Spin on Quantum Magnets* in 2023. From these visits and discussions during the weekly program barbecues at the Munger Physics Residence with other scientists, the idea of FACTS was born.

The administrative and funding structure for IRLs was already in place at CNRS, and the center's leadership, along with KITP Director Lars Bildsten and UCSB Executive Vice Chancellor David Marshall, were very excited about the idea of this partnership between the two prestigious institutions. FACTS aims to strengthen ties in science between France and the US and international collaborations in general, while unifying less-studied aspects of condensed matter and biophysics fields.

by Lucile Savary
FACTS Director, CNRS Permanent Researcher

Astrophysical Simulators Team Up to Better Understand Binaries and Disks

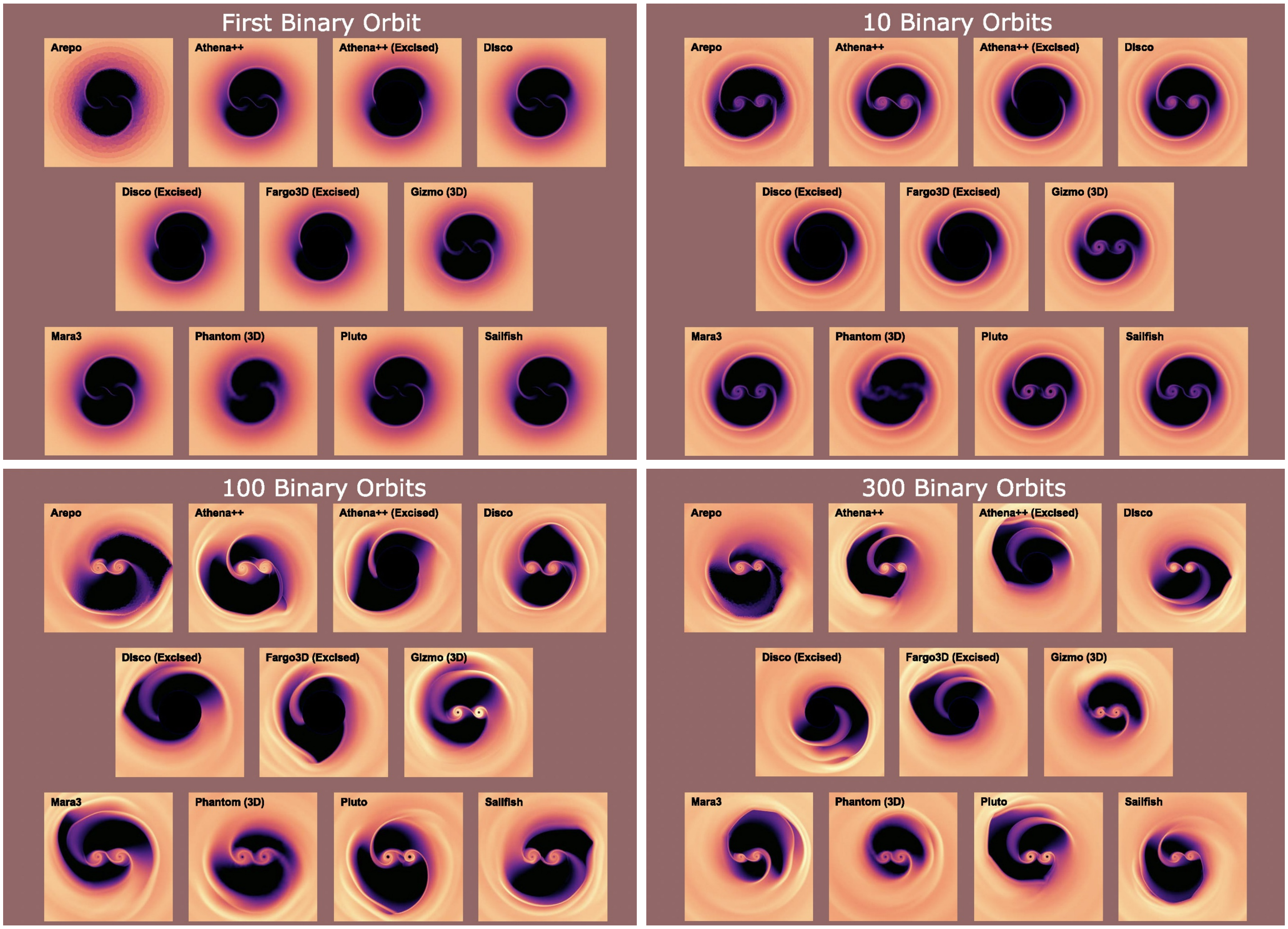
In the Spring of 2022, KITP hosted the program *Bridging the Gap: Accretion and Orbital Evolution in Stellar and Black Hole Binaries*. This program brought together researchers across a wide range of fields in astrophysics, who were all interested in understanding the same basic physics problem applied to many different astrophysical scenarios on many different length and time scales.

One important open problem is the interaction of a binary star with a disk of material circulating within and around it. This arises in different astrophysical scenarios, such as a stellar binary system at an early age when the stars and their planets are first forming. Or the binary could be a pair of black holes accreting gas and emitting powerful outflows observable across the universe. There are, of course, differences in the details between these systems, but (we think) some of the same basic physical laws apply to both.

The researchers attending this KITP program wanted to understand different basic questions about a binary interacting with a surrounding disk. When a binary star system forms, how does the disk affect the binary's orbit? When we see bright emission from an accreting black hole, how can we tell whether it's a single black hole or a binary? And if it is a black hole binary, how does the disk affect the gravitational waves produced by the binary? How do binary stars affect the disk surrounding them, and therefore the planets that subsequently form in this disk?

COMPUTATIONAL APPROACH

A powerful way of investigating these questions is with large-scale hydrodynamical calculations. The equations of gas dynamics are integrated on the computer using a hydrodynamics code, and concrete answers to the above questions can be attained in a few idealized cases.



Surface density for all codes at 1, 10, 100, and 300 orbits. Credit: Duffell et al.

As one might imagine, since this is such a pivotal problem in astrophysics, many teams of researchers have simulated this on the computer. In fact, it has been investigated with at least a dozen different computational approaches and distinct codes, sometimes arriving at seemingly contradictory answers between research groups. As an example, some groups disagreed on such a fundamental question as "does the presence of the disk cause the binary's orbit to get wider or contract closer? " The fact that there was still disagreement on such a basic question demonstrates that this is a hard problem that is not easy to simulate.

When everyone has their own code, and not everyone agrees on the answer, it's easy to blame disagreements on differences between codes. "Your code doesn't resolve the gas well enough." "Your code doesn't conserve angular momentum." "Your code doesn't evolve the binary self-consistently." Such discourse can be useful sometimes, but it also entrenches us in our own camps, with our own codes and our own opinions about the "correct" answer.

THE CODE COMPARISON

With that in mind, during this KITP program, a multitude of researchers across disciplines, many in frequent direct competition with one another, set aside their differences and tested all their codes' performance on a single benchmark test problem. This was known as the "Santa Barbara Binary Disk Code Comparison". A comparable project initiated at KITP was the "Santa Barbara Cluster Code Comparison". Performed in 1999, 13 different groups tested their codes' ability to simulate structure formation in the early universe. The paper describing those results (Frenk et al. 1999) has now been cited more than 400 times. The Santa Barbara Binary pulled together 16 different researchers using 11 very different numerical methods.

The phrase "code comparison" is a bit of a misnomer. It invokes the idea that we're competing to see which code is "the best". Really, the goal was to see if we can reach a consensus solution as a community, and if so, what is necessary for each code to converge to this solution? This attitude was an important component of the project, because if the different simulators thought of this as a competition, we might retreat to our camps claiming the other groups' codes were just "doing it wrong".

KITP provided an ideal neutral ground for the code comparison where everyone felt comfortable sharing their code's output data without worrying if it would be turned against them, or used to argue their code was not trustworthy. A great deal of trust is necessary for a project like this, and the thoughtful design of the KITP programming and atmosphere creates a climate of trust and mutual respect, even among fierce competitors.

The comparison was successful at establishing a benchmark solution that all codes could agree on (for example, all codes agreed that the disk torques the binary outward for the benchmark problem, and they even agreed on the strength of this torque). We anticipate this will have a very strong impact in both relevant fields of stellar and black hole binaries. We anticipate a particular impact on early-career researchers trying to break into the field and getting their codes off the ground. There is now an agreed-upon test problem with public data output from all participating codes—representing the state-of-the-art—that anyone can test their own code against.

The work was published in *The Astrophysical Journal* in 2024 and reads almost as an unofficial review of the field. The code comparison represents the best of what academic collaboration can be. We disagree, we debate, and we are critical of one another, but at the end of the day, we all want to understand what's really going on. Under the right conditions, like those at KITP, we can get together and honestly assess whether or not we really disagree, or if we are just asking different questions.

by Paul Duffell
Professor, Purdue University

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