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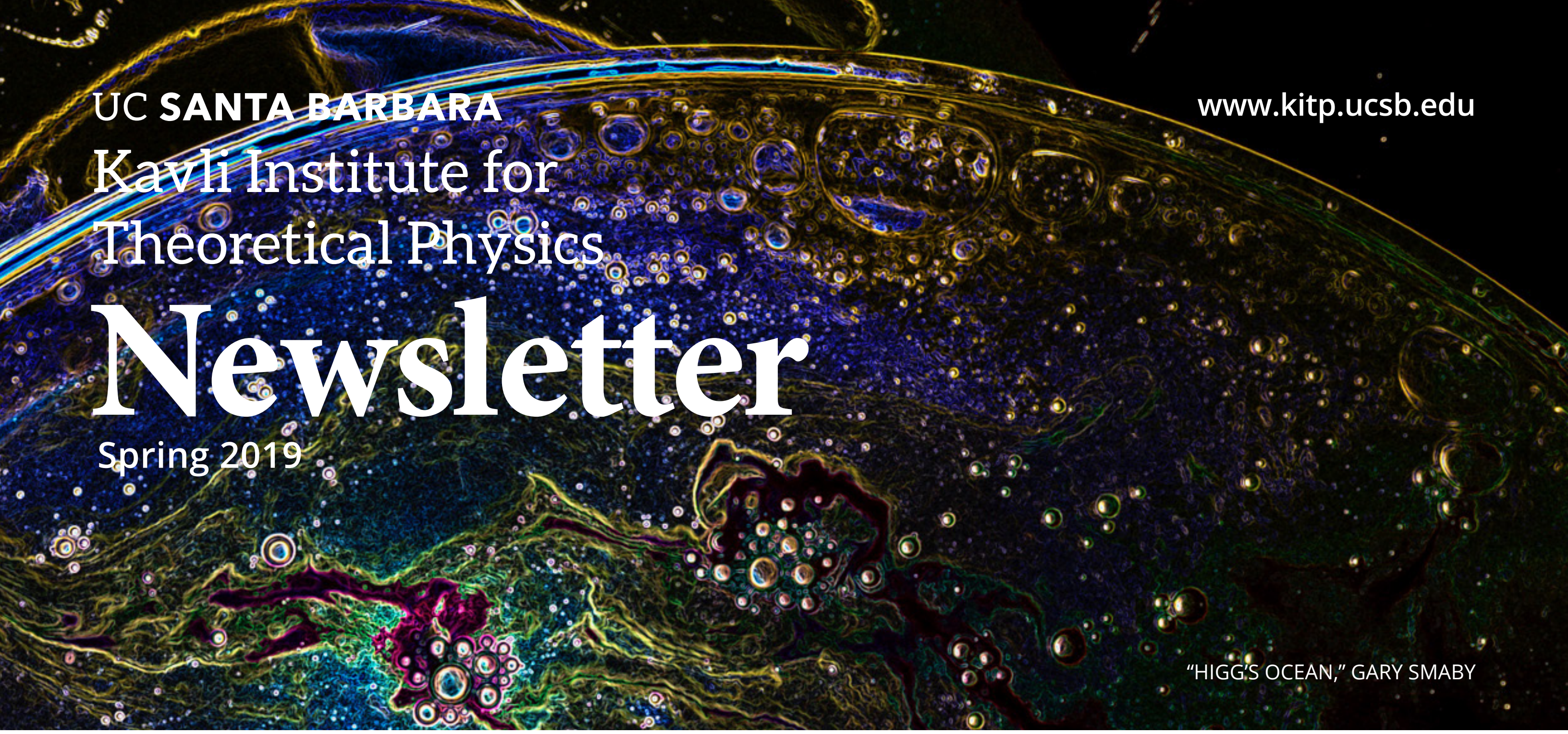
Kavli Institute for Theoretical Physics

Newsletter

Spring 2019



"HIGG'S OCEAN," GARY SMABY

JAKUB OSTROWSKI

Lars Bildsten

Our cover image for the Spring Newsletter is from Gary Smaby, a long-time KITP friend and supporter. Gary worked closely with us during the construction of the Munger Residence and, in collaboration with KITP Artist in Residence Jean-Pierre Hébert, led the production and placement of art in the new building. Once everything had been completed it was clear that there was just one thing missing: Gary's art! This Spring, we were able to work with him to select, produce and hang many of his pieces throughout the Munger Residence. These range from his remarkable black and white photographs of 70's rock legends in our music practice room to his wonderful abstractions of photographs of everything from lichens to astronomical nebulae. A few are even in Glenn's Game Room complementing the cool, classic Pin-Ball machines in the room donated by Glenn Duval. Glenn's Game Room was just named in recognition of Glenn and Bettina Duval's generous support of KITP Graduate Fellows.

Our new Residence Manager Carlos Marquez has been with us for eight months, and his story of rising up through UCSB's well-run Housing operation on page 2 is an inspiring read. The back cover features another great story from the Munger Residence about Estelle Inack, a visitor originally from Cameroon who noticed that we were missing her national flag in the Hall of Flags. Flip to the back page to find out how our Residence team was able to save the day!

Our faculty continue to be very impactful. Starting in 2019, David Gross, KITP Permanent Member and Chancellor's Professor, has taken on the role of President of the American Physical Society, the premier organization in service to the US Physics Community. This prestigious position is giving David the opportunity to shape the future of the physics community while also working to ensure that Congress and other government agencies support basic research! Leon Balents, KITP Permanent Member and Yzurdiaga Professor, was elected to the National Academy of Sciences in early May 2019 and will also serve as a Co-Director of the Canadian Institute for Advanced Research's Quantum Materials program. Don't worry, Leon's not moving to Canada! Rather, this will give him additional opportunities to shape international research.

Led by Boris Shraiman, KITP Permanent Member and Gurley Professor, the KITP has enabled new scientific interactions between biologists and physicists. The most intense events we hold are the yearly Santa Barbara Advanced School of Quantitative Biology. Always held in conjunction with a KITP scientific program, this summer school allows for an exploration of novel research questions while learning new laboratory techniques. Page 5 features a story written by one of our long-term participants, Dr. Honour McCann, about the prolonged exploration of an epiphyte (a plant that grows on the surface of another plant) on kiwifruit. This involved both field work (in Nipomo) and later lab work. Enjoy reading about the path of research they discovered!

Programs at KITP bear scientific fruit on long-timescales. A long-standing fundamental challenge in astrophysics is to definitively associate astrophysical events with the forging of the chemical elements. Jennifer Johnson tells her story on page 4 about a KITP conference she attended in 2008 where she and Inese Ivans found a way to visually clarify where these elements are made in the Universe. Their work is now the classic display tool of these complex origins.

Another example of prolonged effort is the note written on Page 3 by Deputy Director Mark Bowick on the now famous Sachdev-Ye-Kitaev (SYK) model for strongly interacting quantum systems and its correspondence to a two-dimensional model of gravity. A pure theoretical result, it's these kind of stories we theorists love!

A large part of KITP's mission is in identifying and supporting early-career scientists to participate at KITP for prolonged periods of time. We invite more than a dozen graduate students every year to be with us for six months as Graduate Fellows, and we hire 3-5 new postdoctoral Scholars (i.e. postdocs) every year. The postdocs are with us for about three years, allowing them to engage in nearly 30 scientific programs and meet thousands of physicists. KITP faculty provide mentoring with the goal of enabling these postdocs to use their time with us to define their own research agenda and scientific path. Pages 6 and 7 tell the story of two such postdocs, Daniel Holz and Scott Hughes, who were with us over fifteen years ago. The classic paper they wrote, entitled: "Using Gravitational-Wave Standard Sirens" has been cited over 250 times, and, most importantly, laid the ground-work for a new approach to measuring the expansion of the Universe that was first performed last year with the detection of the merger of two neutron stars. It's an amazing story of collaboration!

In closing, I want to update you on one important development for the Santa Barbara community. A participant in our "Physics of Dense Suspensions" program, Douglas Jerolmack (U. Penn), was here during the Montecito debris flow of January 9, 2018 and carried out immediate field work with Professor Thomas Dunne of UCSB's Bren School. Since then, Professor Dunne has received funding from a Montecito resident that is allowing for their collaborative work to continue. They now have a postdoc who is examining the complex flow behavior of the materials that made the debris flows to determine how burned soil may be different from unburned soil. Results are not out yet, but we will be sure to let you know what they have learned when the time is right.

~ Lars Bildsten, KITP Director

Seizing Opportunity

Carlos Marquez, new manager of the Charles T. Munger Physics Residence, reflects on a long and fruitful career on campus

SONIA FERNANDEZ

Longtime staff member Carlos Marquez, now is his 28th year on campus, is the new manager of KITP's Charles T. Munger Physics Residence

Carlos Marquez wasn't too long returned from a four-year stint with the U.S. Army and looking for steady work when his brother referred him to his own employer, UC Santa Barbara. It's a solid job, his brother promised, one he could settle into for a while.

Did he ever.

Fast forward to present day and Marquez is in the midst of his third decade on campus — his 28th year, to be exact (brother Raul, meanwhile, is going on 40 years).

After spending all of his preceding years working for the housing department, Marquez has taken up a new role. Now part of the KITP team, Marquez manages the Charles T. Munger Physics Residence — a world-class housing facility for visiting researchers to KITP. "I love coming to work," Marquez said recently. "I'm meeting people from all over the world here — people from Israel, Cape Town, India, Eastern Europe. Where else can you do that? You just don't know who's going to walk through that door. It's like that every day. It's amazing."

Curiously, the most interesting guest at one of his earlier job sites perhaps foretold, somehow, Marquez's current assignment: None other than the prominent physicist Stephen Hawking. "We used to house Stephen Hawking at family student housing — he would stay at one of our cottages when he was visiting campus," recalled Marquez, who grew up in Santa Barbara and attended both Santa Barbara High School and Santa Barbara City College. "That was one of my highlights, and that was many years ago. I guess I've come full circle now that I'm working for KITP. Who would've thought?"

The same could be said for much of Marquez's tenure at UC Santa Barbara, which he began with something of a shrug but soon grew into a rewarding career. Deciding from the start to do everything possible to advance within the university, Marquez has made good on that over and over again, working on a custodial crew, then leading one, and eventually rising to become a housing supervisor, then a manager. His ethos around work, Marquez said, was gleaned over four years in the infantry: "Teamwork, leadership, attention to detail. There's no problem big enough that you can't resolve. Staying cool and calm, not overreacting. There's always going to be different situations but knowing you have a great support team to help you get through it."

"I first started here in custodial maintenance," Marquez said. "In the Army our sergeants would do the white glove test in our barracks, so I figured I could do some cleaning, with the emphasis of being able to move up within the system. Housing gave me that opportunity — professional development courses, supervisor certificate programs, management classes. The more classes I took, the more I learned, and the more I realized about UCSB: What a great place to work."

By all accounts, the feeling is mutual.

The first time Marquez walked through the door of the Munger Physics Residence, it was as a supervisor for the housing staff, called in to help maintain the just-built facility. He quickly made an impression on KITP Director Lars Bildsten, who began consulting with Marquez on myriad questions and concerns about building operations. "I first met Carlos in fall 2016, when he assembled the career housing staff team to maintain the Munger Residence," Bildsten recalled. "Working together with our founding Residence Manager James Brill, we opened the building and shared the fun and excitement of final inspections. In the intervening two years, James and I would always reach out to Carlos for advice and counsel on the many vexing issues that arise in operating a 75,000 square-foot house for 61 physicists. His advice was always spot-on, allowing KITP to navigate many challenges of operations over the first two years. It's simply wonderful that we have been able to now attract Carlos to be our Residence Manager. He knows how to get things done."

Marquez has done a lot.

Over the decades he has worked at all of the main campus residence halls, as well as university apartments and housing facilities on west campus and in Isla Vista. Characterizing his new role at KITP's high-profile Munger Residence as something of a personal pinnacle, Marquez credits much of his success to the colleagues and co-workers he's met along the way. "I always say, 'I didn't get here by myself, I had help,'" Marquez said. "And my little bit of wisdom: If somebody has helped you out, then make sure you help another person. Extend a hand as someone did to you, so when you leave you know you helped somebody else move up. Many people did that for me, so now that's my gratification — helping people out.

"This is an amazing job, and that's what picks you up and makes you come to work every day," he continued. "A good team, good people that work for you, good leadership. What else can you ask for? I'm so grateful to be in the spot where I am right now. I'm enjoying what I'm doing and I love getting up every morning and coming here, meeting and greeting people. So I'm very grateful to be here and to have been here this long. The time has flown. After 28 years at UCSB, this may be my last chapter — but it's going to be a great chapter."

~ By Sonia Fernandez, UCSB Public Affairs

Leon Balents Appointed Co-Director of CIFAR's Quantum Materials Program

MATT PERKO

KITP Permanent Member, Leon Balents

Scientists have known for a long time that nature is quantum, following physical principles — at the atomic and molecular levels — that to the naked eye would seem counterintuitive and downright surreal. According to Leon Balents, KITP Permanent Member and Yzurdiaga Chair of Theoretical Physics, these quantum behaviors can be harnessed to produce materials and technologies with properties we've only dreamed of, as well as applications we haven't even thought of yet. "Quantum materials are materials — solid substances — whose electrons act together to produce surprising properties relying on the quantum laws of nature," said Balents. "Quantum materials can provide new means to convert waste heat into usable energy, to build exquisitely accurate sensors, and to transmit power with ultra-low loss."

And now, as a new co-director of the Canadian Institute For Advanced Research (CIFAR) Quantum Materials program, Balents is poised to contribute both his expertise in correlated electron systems, quantum magnetism and complex materials, and his leadership to aid the success of this collaborative endeavor. CIFAR is a Canada-based, global charitable organization that convenes extraordinary minds to address science and humanity's most important questions. By supporting long-term interdisciplinary collaboration, CIFAR provides researchers with an unparalleled environment of trust, transparency and knowledge-sharing. A mission very similar to that of the KITP.

"I'm honored to take on this leadership role in CIFAR's longest-running program, which has played a seminal role in its area of quantum physics," Balents said. "The Quantum Materials program led the world to advances in high-temperature superconductivity, and has since broadened to embrace, and in fact define, the field of quantum materials. These are the logical successors of the semiconductor materials which underlie today's electronics, and will be used to create the quantum computers of tomorrow," Balents said. "As a new CIFAR co-director, I aim to advance this field by convening the best minds and most creative scientists in the field for intense brainstorming, collaboration and training for young scientists in this dynamic field. I hope that I can both help the program to engage internationally while supporting the Canadian community from which it springs."

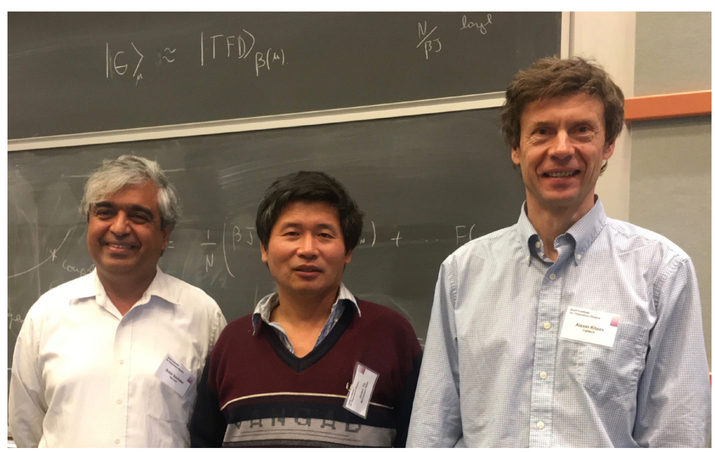
~ By Sonia Fernandez, UCSB Public Affairs

Quantum Metals Meet Gravity

Theoretical breakthroughs often take time to reach fruition. Our Fall 2018 KITP program "Chaos and Order: from Strongly Correlated Systems to Black Holes" was triggered by progress that occurred in two distinct steps over a period of more than twenty years. A paper in 1993 and a series of talks at KITP in 2015! These remarkable insights are now referred to as the SYK (Sachdev-Ye-Kitaev) model.

This research thread was first introduced and studied by Subir Sachdev, at Yale at the time, and his first PhD student Jinwu Ye. Most analytical methods of many-body systems assume that the interactions between the particles are weak, only slightly perturbing their motion. In that case the calculations are relatively simple. Quantum many-body systems with much stronger interactions are, in contrast, notoriously difficult to deal with. In their landmark 1993 paper published in Physical Review Letters, Sachdev and Ye sought to understand the possible phases of strongly interacting quantum metals or magnets (a system of spins). Remarkably, they found a transition from a glassy-like phase to a fluid-like phase that is not possible with weak interactions.

In 2015 Alexei Kitaev, then a Permanent Member at KITP, gave a series of talks that showed that the Sachdev and Ye model was both chaotic and exactly solvable. He also showed that its unique properties allowed it to be recast as a two-dimensional model of gravity! Deep insights into strongly-coupled condensed matter systems may now be gained by exploiting our understanding of the corresponding gravitational theories, even though the elementary degrees of freedom look completely different. This has sparked a large amount of research, motivated our program and also led to convening all three physicists at the KITP: S, Y and K!

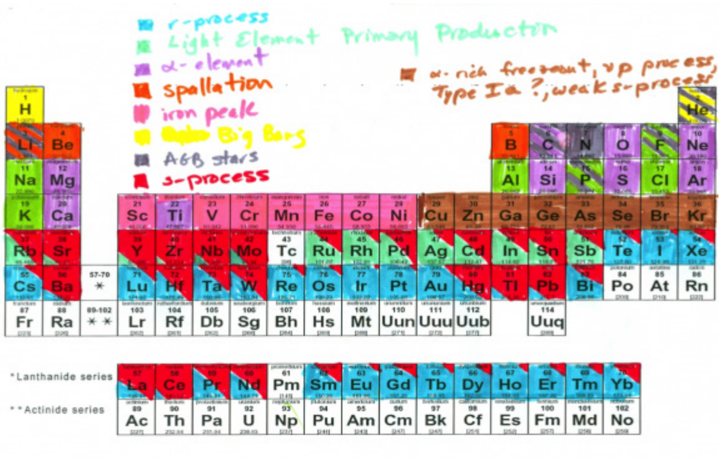


SUBIR SACHDEV

L to R: Subir Sachdev, Jinwu Ye and Alexei Kitaev at a program at KITP

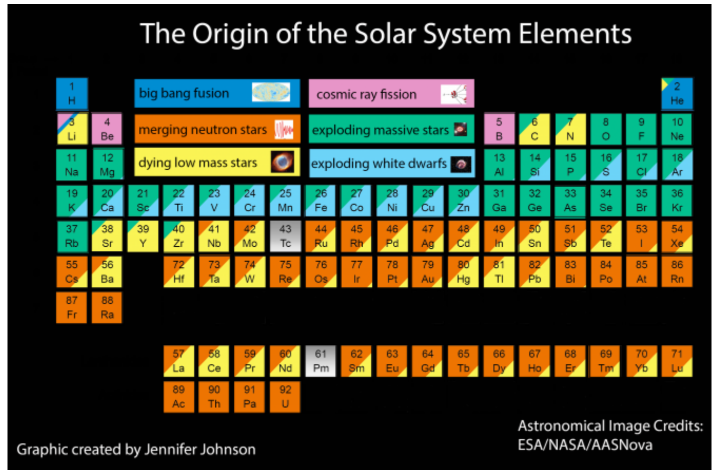
~ By Mark Bowick, KITP Deputy Director

Marking up the Periodic Table at KITP



INESE IVANS/JENNIFER JOHNSON

The periodic table color-coded by the source of the element in the solar system, hand-drawn at the 2008 "Back to the Galaxy II" conference.



2018 version of the evolving periodic table color-coded by the element's source.

One of KITP's goals is to bring together theorists and experimentalists with different expertise to intensively study important issues. One such conference was 2008's "Back to the Galaxy II," where astrophysicists interested in understanding the history of the Milky Way gathered at KITP. The conference brought together experts on dark matter, orbital motions, gas dynamics and hydrodynamics, and finding the smallest galaxies around the Milky Way. Our research area, studying the chemical compositions of stars of different ages, was well-represented. The atmospheres of stars are chemical time-capsules of the gas from the time the star was born. Because each element in a star's atmosphere absorbs light at a characteristic wavelength, we use spectroscopy to infer which elements are present, and their relative abundances. Each type of star produces different elements, in a characteristic lifespan. By measuring the amounts of each element in many stars, we can piece together which and how many of our Galaxy's stars were born, and when.

The assembled scientists knew that, if we wanted to understand the Galaxy's evolution, we couldn't just concentrate on one element. This meant that over 40 elements were appearing on plots during the conference, and if your expertise lay somewhere else, keeping track of which kind of star made which elements was too much to manage. It became a stumbling block in the cross-disciplinary discussions that are so important in making progress on big questions. In the spirit of KITP conferences, we decided to help our fellow astrophysicists by providing a simple graphical version of the periodic table, color-coded by the technical names of the stellar processes that we were all discussing.

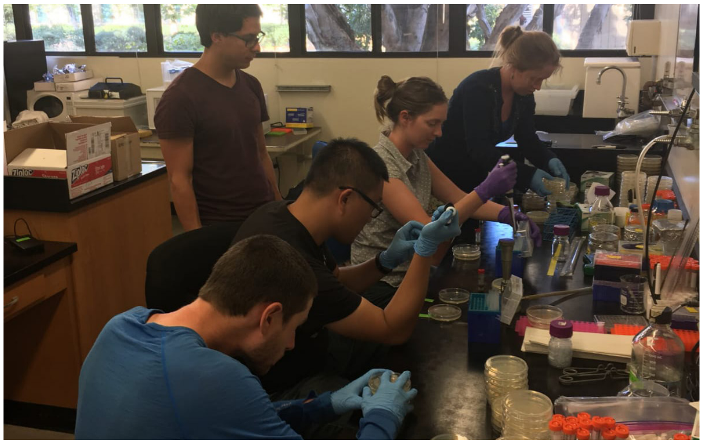
One of the unsung benefits of KITP is its close proximity to the community of Goleta, with its drugstores that sell magic markers. KITP also has printers, where we could print periodic tables found on the internet. Over the course of a conference session, we color-coded the chart below. (We were also paying attention to the talks, we promise!)

This highlighted areas where astronomers' knowledge shifted from "we got this" to "come back in a few years." For example, theorists have figured out several ways to make the heavy elements just past iron, but we don't yet know how much is contributed by each exotic-sounding process encoded in brown on the 2008 table. Since the 1950s, we have known that these heavy elements are made both by rapid neutron-capture and slow neutron-capture (r- and s- processes), but there were several candidates for the site of the r-process. It was a thrill when, in 2017, the neutron-star merger detected in both gravitational waves and electromagnetic radiation confirmed one of those sites. However, supernovae remain a possible site for r-process, particularly for the elements up through Zirconium (Zr). Dividing up the turquoise bits of the table into "merging neutron stars" and "supernovae" is one of the remaining challenges.

We did draw three definitive conclusions from this effort: (1) Jennifer's handwriting is really bad, (2) Inese's idea of using diagonal blocks to show the fractional contribution of each process in the lower part of the table is elegant and striking, and (3) many people have found this graphic very helpful, so thank you, KITP!

~ By Jennifer Johnson, Profesor of Astronomy at Ohio State University, and Inese Ivans, Assistant Professor of Physics and Astronomy at University of Utah

A Fruitful Collaboration Continues



Clockwise from upper left: Regalado, McLaren, Liu, van Raay, and Seward culturing P. graminis during their fall 2018 visit.

Each summer, the Santa Barbara Advanced School of Quantitative Biology runs alongside a KITP biology program, distinguishing itself by linking the program's critical discussion and exploration of important theoretical topics to the lab projects. This school, funded by the Gordon and Betty Moore and Kavli Foundations, affords PhD students and postdocs the opportunity to learn new techniques and explore novel research questions in a dynamic, collaborative atmosphere. The group project we initiated during the Summer 2017 course on Eco-Evolutionary Dynamics in Microbial Communities has become an enduring collaboration.

Our group includes students and postdocs from different disciplines, bringing together experience with experimental approaches, bioinformatic analysis, and theoretical population genetics. Together, we formulated and began to investigate a novel research direction, aiming to understand spatial population structure and patterns of horizontal gene transfer (as opposed to vertical, parent to offspring inheritance) in a bacterial epiphyte. An epiphyte is a non-pathogenic organism that grows on the surface of a plant.

We began the project with an exploratory sampling trip to Mallard Lake Ranch, a kiwifruit farm in Nipomo (California). We wanted to determine whether the non-pathogenic bacterium *Pseudomonas syringae*, frequently found in association with kiwifruit in New Zealand and East Asia, could be recovered from California orchards. When we sequenced *Pseudomonas* isolated from both leaf surfaces and within leaf interiors, we were surprised to find that there was no *P. syringae* among them, and that over half the Mallard Lake Ranch isolates were *P. graminis*. Comparatively little is known about *P. graminis*, other than that it exhibits antagonistic activity against a plant pathogen, may serve as a biological control and soil remediation agent, and has been isolated from cloud water. This suggests that *P. graminis* is a non-pathogenic epiphyte that may be distributed by local or global water cycles.

Our sampling spanned spatial scales from centimeters (within a leaf) to hundreds of meters (across the orchard), providing a unique dataset for population genetic analysis of patterns of growth, dispersal, and recombination in a wild population of bacteria. Our analysis found multiple, coexisting, divergent lineages across the orchard; within a single vine; and in some cases even within a single leaf. We were also able to assess the amount of dispersal within and among vines and the degree of clonality within a leaf.

Despite the demands of our work at institutions around the world, we continued our conversations and analysis after the course finished. We decided to take advantage of KITP's Follow-On program, funded by the Kavli and Moore Foundations, which invites program participants back to KITP to continue collaborations initiated on an earlier visit. The Follow-On allowed us to reunite at KITP in spring 2018 for data analysis and discussion. We assembled at KITP again in fall 2018 for a second visit to Mallard Lake Ranch. On this second sampling trip, we specifically targeted *P. graminis* and obtained a set of isolates that allowed us to assess how spatial diversity had changed over time. This approach recovered *P. graminis* from every plant sampled, an outstanding outcome given that the field and laboratory work was completed in just two weeks. This work will provide insight into how microbial diversity is structured at multiple spatial scales over time and form the basis of a manuscript that grew out of the rare privileges that KITP provides: freedom and time.

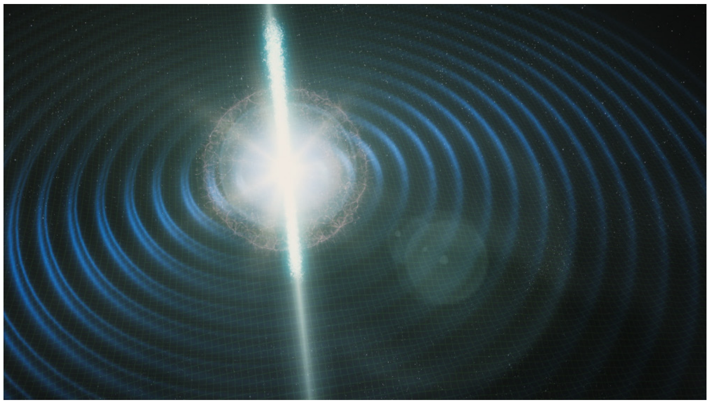
(L to R): McLaren, Regalado, Seward, and Liu collecting kiwifruit leaves at Mallard Lake Ranch.

(L to R): Regalado, McLaren, McCann, Liu, and van Raay on a break outside Kohn Hall

The Kiwifruit Dream Team: Julian Regalado (Max Planck Institute for Developmental Biology), Katrina van Raay (University of Washington), Michael McLaren (North Carolina State) and Xianan Liu (Stony Brook University, SUNY) participated in both the QBio course and one (XL) or both (JR, KvR, MM) Follow-Ons; Elena Colombi (Massey University) participated in the second Follow-On; Wei Ding (Max Planck Institute for Developmental Biology) and Emily Seward (Oxford University) participated during the QBio course.

~ By Honour McCann, Lecturer at Massey University's New Zealand Institute for Advanced Study

The Standard Siren



FERMI LAB

Two neutron stars collide, sending out gravitational waves and electromagnetic radiation detected on Earth in 2017.

Ten years before the detection of gravitational waves, two KITP postdocs had a novel idea.

The history of science is filled with stories of enthusiastic researchers slowly winning over skeptical colleagues to their point of view. Astrophysicist Scott Hughes can relate to these tales.

"For the first 15 or 16 years of my career I was speaking to astronomers, and I always had the impression that they were politely interested in what I had to say, but regarded me as a little bit of a wild-eyed enthusiast who was telling them about a herd of unicorns that my friends and I were raising," said Hughes.

"Now," he continued, "there are people who are going, 'Ooh, all those unicorns you found, can I use them to solve my problem? Do your unicorns have wings? Are they sparkly?'"

These unicorns are gravitational waves, an area of physics in which Hughes specializes. While working as postdoctoral researchers at KITP, Hughes and his colleague, Daniel Holz, were among the first to propose using the phenomena, in combination with telescope-based observations, to measure the Hubble constant, a fundamental quantity involved in describing the expansion of the universe.

As the universe expands, it carries celestial objects away from us. This stretches out the wavelength of light we detect from these objects, causing it to drop in frequency just like a siren on a passing ambulance. The faster the object is receding, the more its light will shift toward the red end of the spectrum. The Hubble constant relates an object's distance from Earth to this redshift, and thus the object's speed as it's carried away.

One of an astronomer's best tools for calculating this is a standard candle, any class of objects that always have the same, standard brightness. If scientists know the brightness of an object, they can determine its distance by measuring how dim it appears to us on Earth.

For decades scientists have tried to get accurate measurements of the Hubble constant in order to investigate why the universe is expanding, and, in fact, accelerating. This ultimately resolves to measuring objects' redshifts and matching them with independent measurements of the objects' distances from us. However, these two most accurate measurements scientists currently have for the Hubble constant disagree — an endless source of frustration for cosmologists.

A Proposal

This was the cosmological landscape in the early 2000s when Holz and Hughes held positions as postdoctoral researchers at KITP. "Scott had been thinking about gravitational waves for a while," said Holz. "He was the expert, and I was much more focused on cosmological questions." But Hughes' enthusiasm soon piqued Holz's curiosity, and the two began to talk about gravitational wave cosmology in the office and on walks along the Santa Barbara bluffs.

Holz and Hughes credit their close collaboration to the construction of the new wing of Kohn Hall in 2001. Initially, all postdocs at KITP had their own offices, explained Hughes, but the construction (funded by Fred Kavli and the Kavli Foundation) forced them to double-up. "Suddenly we were spending a lot more time with each other."

A 2002 KITP program on cosmological data fanned the flames of their interest in the topic. By the time Hughes left to join the faculty at MIT, they had finished the first draft of their paper detailing how to calculate the Hubble constant with gravitational waves. After two years gestating they finally published the study in The Astrophysical Journal. "I had a great time writing that paper with Scott," said Holz. "I learned an incredible amount. So much that I was convinced that gravitational waves were the future, and that I should get involved."

The idea of using gravitational wave sources to measure the Hubble constant was not new. The concept was first proposed in a visionary paper in 1986 by Bernard Schutz. And a number of other notions regarding gravitational waves were also floating around the literature in the early 2000s. But what Holz and Hughes did was synthesize all these ideas and emphasize the feasibility of combining data from gravitational waves with follow-up observations using light.

The study also was the first to use the term "standard siren." Hughes recalled discussing the paper with Caltech astrophysicist Sterl Phinney, who remarked, "Hmm. Kind of like a standard candle, but you hear it. You should call it a standard siren." Holz independently had an almost identical conversation with physicist Sean Carroll, a former KITP postdoc himself. Holz and Hughes included the term in their paper, and it stuck. The phrase has since become ubiquitous in cosmology. "The term 'standard siren' might be our most lasting contribution, Scott," Holz remarked. "I'll take it," laughed Hughes.

Using gravitational waves to measure the Hubble constant has

MIT AND UNIVERSITY OF CHICAGO

Former KITP postdoctoral scholars Daniel Holz and Scott Hughes

many advantages over other methods. Certain supernovae provide decent standard candles, "but, as a standard candle, supernovae are not very well understood," said Holz. "The main thing that makes standard sirens interesting is that they're understood from first principles, directly from the theory of general relativity."

When using standard candles, scientists have to calibrate the distances of certain classes of objects using the information from other ones, effectively leapfrogging their way to a proper distance measurement. Astronomers call this method a "distance ladder," and errors and uncertainty can creep in at many points in the calculations.

In contrast, gravitational waves can provide a direct measurement of an object's distance. "You just write down the equations and solve them, and then you're done," said Holz. "We've tested general relativity for a hundred years; it really works, and it says 'here's how far that source is.' There's no distance ladder, there's none of that fiddling around."

All the early papers on measuring the Hubble constant using gravitational waves were somewhat speculative, according to Holz. They were proposals for the far future. "We hadn't even detected gravitational waves yet, much less waves from two neutron stars, much less with an optical counterpart," he said. But interest and enthusiasm for the technique were growing.

Hughes remembers colleagues coming up to him after his talks and asking about the likelihood of observing a standard siren in the next decade. He didn't know, but he did say that with a better understanding of the optical counterpart, they could probably localize an event to within 10-20 square degrees. "And I think if you have that, every piece of large glass on Earth is going to stare at that spot on the sky," Hughes had said. "And, in the end, that is exactly what happened."

And Then It Happened

On August 17, 2017, less than two years after detecting the first gravitational waves, the LIGO and Virgo observatories recorded a signal from merging neutron stars. Thanks to an alert system, which Holz helped establish, a flurry of activity followed as nearly every major ground and space-based observatory trained their sights on the event. Scientists collected data on the merger in every region of the electromagnetic spectrum.

Suddenly, gravitational wave cosmology was a real field, and standard sirens were another part of the toolkit. "But for something to become part of the toolkit so quickly? That's extraordinarily unusual," said Holz.

It turns out that cosmologists need another tool, because they currently have two different values for the Hubble constant. Methods using the cosmic microwave background — faint light left over from the big bang — yields a value of around 68. Meanwhile, calculations that use Type Ia supernovae — a variety of standard candle — yield a bit more than 73. Although they appear close, the two values actually differ by three standard deviations, and both have fairly tight error bars. The disagreement has cosmologists increasingly concerned as the error bars on these two values only get tighter. It could signal a fundamental problem in our understanding of the universe, and is the subject of a KITP Conference in July 2019.

There are a few intrinsic differences between the two techniques, though. The cosmic microwave background reflects the conditions of the early universe, while the supernovae paint a picture of the current universe. "There's a chance that maybe something very strange and unexpected has happened between the early and late days of the universe, and that's why these values don't agree," said Holz. But cosmologists simply don't know for sure.

Getting another, independent value for the Hubble constant may clear up this conundrum. "Because it's so clean and so direct, that measurement will be a very compelling number," Holz explained. "At the very least, it'll inform this discussion, if not just completely resolve it."

Holz and Hughes credit their success to their experiences at KITP. "While working together at the KITP the two of us got excited about measuring the Hubble constant using gravitational waves," said Holz. "And that's exactly what the KITP is about: bringing different people together with different backgrounds, stirring the pot and seeing what happens.

"If both of us hadn't been at the KITP there's no way I'd be spending a good fraction of my life on LIGO teleconferences right now," he added. "But I wouldn't have it any other way."

~ By Harrison Tasoff, UCSB Public Affairs

A Missing Flag

My journey in Physics started in my home country of Cameroon, completing a Master in Physics at the University of Buea in 2013 on the modelling of nerve impulses in biological neural networks. I then obtained a postgraduate diploma scholarship to study Condensed Matter Physics at the Abdus Salam International Center for Theoretical Physics (ICTP). There, my advisor Sebastiano Pilati introduced me to a research direction that involves using statistical mechanics tools to tackle optimization problems.

It was towards the end of my PhD that I noticed the interplay between machine learning techniques and the quantum-inspired classical optimization methods that we were developing. I then decided to enlarge my research interests by jumping into the field of machine learning for quantum physics. It is in this research field that I began collaborating with Roger Melko of the Perimeter Institute. The KITP program: "Machine Learning for Quantum Many-Body Physics", coordinated by Roger, is what brought me to Santa Barbara.

The first thing I saw upon setting foot in the Munger Residence was the beautiful corridor of flags reflecting the international diversity of visitors at KITP. I thought about this representing the inclusive nature of research as is beautifully described by a quote emblazoned on the wall of the entrance of the ICTP, "Scientific thought and its creation is the common and shared heritage of mankind."

As I was going in and out of the Residence every day, I secretly hoped to spot my flag among the concert of nations. One day as I was leaving I saw Carlos Marquez, the Residence Manager, at the front desk. I asked him what the flags represented, and the requirements to have one's flag up on the wall.

He graciously told me that they represented the nationalities of the researchers currently staying at the Residence. I saw the occasion to make my case, gently mentioning to him that my flag wasn't there. He immediately promised to look for it and if they didn't have it, to order one to put up with the other flags. He did just as he promised and I was overjoyed. As if that wasn't sufficient, he gave me the chance to put up the flag myself! I will be forever grateful for that.

ESTELLE INACK

Guillermo Iturralde, Munger Residence staff, helps Estelle to place her flag in the Hall of Flags

My time at KITP was quite special. This was my first visit, and it was wonderful to meet other researchers that I am familiar with, and interact with them in person for the first time. Science is universal and I am very pleased to see that this is the prevailing message even in a leading institute like KITP. I am leaving KITP with a lot of new ideas that I look forward to trying out!

~ By Estelle Inack, Francis Allotey postdoctoral researcher at Perimeter Institute

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Engaging with the KITP

There are many ways to contribute to the life of KITP. We urge you to become involved by:

- **Becoming a Friend of KITP**
- **Attending a public lecture or Café KITP event**
- **Making a Philanthropic Gift**

To do so, call (805) 893-6307, email friends@kitp.ucsb.edu or visit our website at www.kitp.ucsb.edu/support-kitp.

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