Kavli Institute for Theoretical Physics
UC Santa Barbara

www.kitp.ucsb.edu

# Newsletter

Spring 2018

JAKUB OSTROWSKI

Lars Bildsten

I open this Newsletter with a heavy heart. Our good friend and colleague Joe Polchinski passed away in early February 2018. I've since had a chance to meet with his wife Dorothy and speak with her about Joe's remarkable legacy across all of science. Much of what was special about Joe is nicely described by Eva Silverstein in her Quanta Magazine article. Eva and Quanta Magazine allowed us to excerpt much of that article on page 3. Working with David Gross, Rob Leigh and Eva, KITP is organizing a Science Symposium in honor of Joe on December 15, 2018. Given Joe's exceptional impact across all of physics and his remarkable mentoring of early career scientists, I'm sure it will be an exciting event. In the meanwhile, we are working with the University Archivist to ensure that Joe's original calculations are preserved and cataloged for all to see.

On the science front, entanglement has become a large part of what physicists think about every day, especially when together at KITP. Permanent Member Leon Balents focused his inaugural lecture for the Pat and Joe Yzurdiaga Chair in Theoretical Physics on just this topic, as well as the physics of magnetism (see page 4). One of our recent visitors, Roger Melko, was kind enough to write (see page 5) about his experience as a visitor in 2015 when Alexei Kitaev (then KITP Permanent Member, now at Caltech) gave a series of talks that triggered an avalanche of new work exposing deep relations between phase transitions and the quantum structure of space-time. Science takes time to yield, and on Page 6 is a story from Thomas Gasenzer about the germination of an idea while at KITP that has since been published in Science.

The tragedies of the Thomas Fire and the later debris flow in Montecito impacted many in our community. The smoke and ash from the Thomas Fire had an immediate impact on our December 2017 Rapid Response program on the double neutron star merger discovered by LIGO and VIRGO. I applaud KITP's staff for their steadfast efforts during this period to keep the KITP functioning despite recurrent power outages, and the need to move all of the outdoor conference dining into Kohn Hall's interior due to the poor air quality. This was a tough time for everyone, but the spirit of KITP allowed for the event to continue unabated. Read the article on page 2 to get a sense for the exciting science enabled by this singular discovery of the electromagnetic signatures from the merger of two neutron stars!

The Montecito debris flow in the early morning of January 9, 2018 was only a few days after the arrival of a KITP program entitled: "The Physics of Dense Suspensions". To a physicist, a dense suspension is a liquid (such as water) which has many small solid particles within it. The intellectual puzzle is to find the cause of the dramatic increase in the liquid's viscosity as the concentration of the solids increases. What once flowed like water suddenly behaves more like molasses! This description is also very close to the mud that was present in the Montecito debris flow. One of the program participants, Douglas Jerolmack, a faculty member from University of Pennsylvania, became very involved in scientific diagnostic field work in Montecito with Professor Thomas Dunne of UCSB's Bren School. Douglas described their work at the conclusion of his visit to KITP in a remarkable "Chalk Talk" that you can find on our website at: *http://online.kitp.ucsb.edu/online/friends/jerolmack/*

I noted in our last Newsletter that we were in the midst of our renewal of support from the National Science Foundation. We were renewed but at a substantially lower level than the prior grant. This decline in federal funding only highlights the continued need for philanthropy to support KITP's mission. In that regard, we have added one staff member, Megan Turley, who will work with Kristi Newton and myself on development efforts, the Friends of KITP and other important outward looking activities. I look forward to introducing you to her at one of our next KITP events!

As of May 2018, we have been operating the Charles T. Munger Physics Residence for 16 months, and its impact continues to be felt across all of physics. Gerald Dunne, one of our Fall 2017 program coordinators, shares his perspective on the physics impact of the Munger Residence on the back cover.

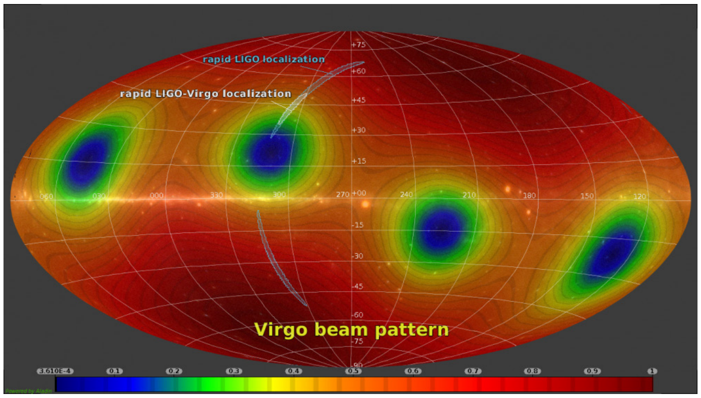
In closing, I also note the passing of Stephen Hawking, a long-time friend and supporter of KITP. Indeed, he gave the inaugural KITP Public Lecture many years ago, as described in the article on page 7.

*~ Lars Bildsten, KITP Director*

# A New Window on the Universe

## KITP hosts a rapid-response program to explore myriad new astrophysical insights from a double neutron star merger

GRECO, ARNAUD, BRANCHESI, VICERE




The blue regions show the localization by the two LIGO detectors, and the much smaller white region includes the Virgo network of detectors.

Two years ago, scientists from the Laser Interferometer Gravitational-Wave Observatory (LIGO) detected gravitational waves for the first time, proving Einstein's theory of relativity and his prediction of their existence. The waves were triggered by two black holes colliding.

On Aug. 17, 2017, LIGO and the French-Italian Virgo detector observed a completely new class of gravitational-wave signal: a binary neutron star merger. This merger and its afterglow were studied by telescopes spanning the entire electromagnetic spectrum from gamma rays to radio waves.

Of fundamental interest to both physicists and astronomers, gravitational-wave observations have ushered in a new era of science. In fact, so many scientific papers about the neutron star merger were published in one day that researchers created an online index to keep track of them.

And, less than two months after that first detection of colliding neutron stars, the KITP convened a rapid-response program for scientists from around the world, directly supported by the Kavli Foundation. More than 75 physicists and astronomers discussed the astrophysics of the neutron star merger and listened to dozens of presentations that delved into the details of this most recent game-changing event.

"The intent of *'GW170817: The First Double Neutron Star Merger'* is to broaden awareness of the results produced by the vast collaboration that made these exciting discoveries," said KITP director Lars Bildsten "KITP provides a place for interested scientists not only to take in the vast amount of data generated by the latest event but also to push interpretations of that data."

The August gravitational-wave signal produced the first distance measurement to a nearby galaxy from the merger of two neutron stars and explored the equation of state of matter at super-nuclear densities. Other areas of study also emerged from the profusion of gravitational-wave and electromagnetic data, including the formation of heavy elements as well as the gamma ray burst and other electromagnetic signals that followed the neutron star merger.

The cosmic origin of elements heavier than iron has been the subject of much debate. Although theoretical models show that matter expelled in a neutron star merger can form into gold and platinum in a process known as rapid neutron capture (r-process) nucleosynthesis, this latest event provides solid direct observation.

"For years, people have been trying to study how the heaviest elements were formed by looking at trace fossil remnants of those elements in the sun or in meteorites," explained UC Berkeley astrophysicist Daniel Kasen, a coordinator of the KITP program. "Finally, with this event we had the pure sample of heavy elements ejected from the neutron star merger and we were able to probe it directly, observationally, by looking at the light from the radioactive glow of those heavy elements."

For a number of years, physicists and astronomers — many of whom attended a longer KITP program on a similar topic in 2012 — have been modeling what a double neutron star merger would look like. It turns out that many models of these extremely complicated phenomena were uncannily accurate.

"The gravitational waves told us that these were neutron stars and the electromagnetic observations told us about the spectrum of the radioactive decay that produce r-process elements," said Duncan Brown, the Charles Brightman Endowed Professor of Physics at Syracuse University and lead coordinator of the KITP rapid-response program. "You put those two together and they complete our knowledge of the origin of the periodic table."

Another hot topic of the program was the immediate electromagnetic counterpart to the neutron star merger. The gamma ray burst raced the gravitational waves 130 million light-years through the universe to be observed on Earth only two seconds apart. This demonstrated that neutron star mergers are the long-sought origin of gamma ray bursts. It also showed that to extremely high accuracy the speed of gravity and the speed of light are the same, which, according to Brown, rules out a large class of modified theories of gravity.

"What has been surprising to me are the discussions of the possible gamma ray burst emission mechanisms," Brown said. "In gravitational-wave astronomy, the theory has been 50 years ahead of the observations, whereas the electromagnetic side is the other way around; the observations are 50 years ahead of the theory. It's going to be interesting to see how this evolves."

Physicists and astronomers will have another chance to explore gravitational-wave science in a future KITP program slated for 2019. "*The New Era of Gravitational-Wave Physics and Astrophysics*" will bring together a broad group of experts to discuss the astrophysics and fundamental physics that can be learned from the observations available at that time, which hopefully will be considerable.

LIGO and Virgo are updating their instrumentation with the hope that when they come back online in fall 2018 with increased sensitivity, their efforts will yield additional observations of gravitational-wave signals, perhaps from other sources.

"They won't all be the same in masses or spins and maybe we'll see a black hole and a neutron star collide into each other," Brown said. "This is really just the beginning of a global effort to use these collisions to study fundamental physics, astrophysics and stellar evolution."

*~ By Julie Cohen, Science Writer, UCSB Public Affairs*

# Mourning the Loss of Joe Polchinski, Developer of Deep Ideas and Paradoxes

## Joe Polchinski, who passed away Feb. 2, left a tremendous professional and personal legacy, says a friend and collaborator Eva Silverstein

In physics, we sometimes make progress through conflict. Thought experiments uncover apparent contradictions that sharpen our theories. In addition, there's often a trade-off between the precision of a calculation and its relevance to an ultimate goal.

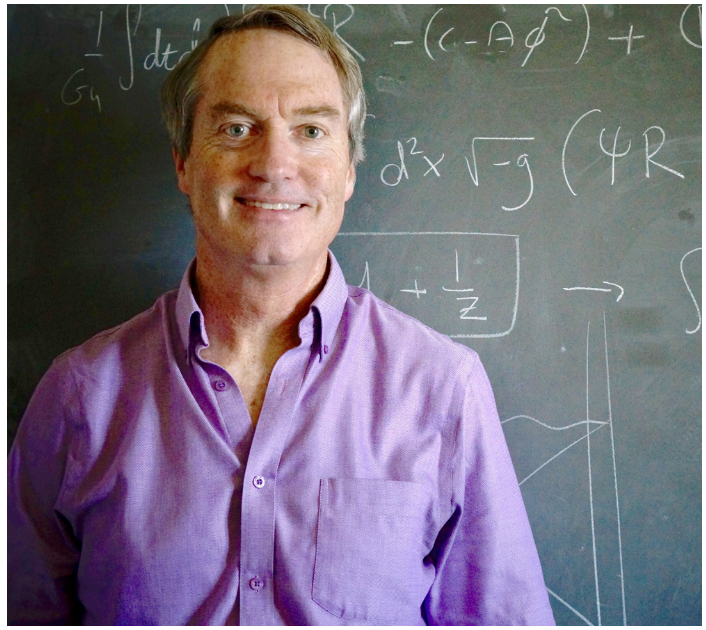
The physicist Joe Polchinski was the rare exception who often managed to avoid such trade-offs. He developed concrete methods relevant to major problems. He also had a knack for uncovering fruitful conflicts, marshaling his own extensive, almost contradictory talents.

Joe was radically conservative, following well-supported physical principles to their logical conclusions, however extreme or surprising. Less circumspect on a road bike, he would tear down a descent. He was irreverent yet dignified, pragmatic but positive. Although competitive, he was a consummate good sport who took joy in the successes of others. The community is reeling from the loss of such a brilliant physicist and extraordinary human being. Joe died earlier this year from brain cancer at age 63.

Polchinski made an enormous impact, not just on theoretical physics but on other physicists. I recall delightfully succinct discussions where we put our finger on the essential crux of a problem within a matter of minutes. Perhaps this efficiency helps to explain how he was able to transcend the limited circles in which most scientists operate. Working for the last 25 years at the KITP, he interacted meaningfully with much of the theoretical physics community worldwide, conscious of the fact that important insights come from all quarters.

Since Polchinski's death, there has been an outpouring of grief and appreciation online. "The memories that come back most vividly involve Joe's sense of fun, his utter lack of pretension and the way he had of treating everyone equally," wrote Markus Luty, a physicist at the University of California, Davis. "Joe did not lower his standards for anyone, but he made those around him feel significant with his intense way of listening and engaging with them."

An avid cyclist, Joe enjoyed epic rides with friends, exploring the mountainous landscapes in California, Colorado and beyond. These high-spirited, intense adventures also led to more physics, at least when it was possible to hold a conversation. On one occasion, a few of us were drafting behind Joe, and he inadvertently led us off road, later explaining that he'd been thinking about entropy. In Santa Barbara, he took varied groups of physicists up Old San Marcos Road, delighting in the progress of new riders. He pushed himself hard and applauded his friends enthusiastically whether ahead or behind him on the road.



SONIA FERNANDEZ

Joe Polchinski at the KITP at UC Santa Barbara in 2014.

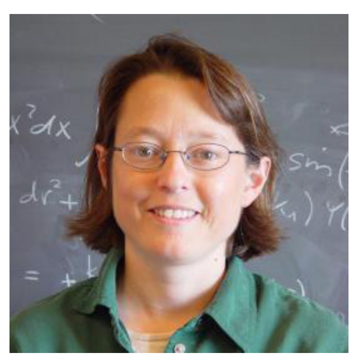
COURTESY OF EVA SILVERSTEIN

Polchinski cycling in the mountains near Santa Barbara.

I worry about the loss of his perspective, which has been indispensable at times as the field tries to converge on the right answers or, in lieu of answers, the appropriate level of uncertainty. As the community mourns his loss and celebrates his major contributions, we have our work — and fun — cut out for us on the questions he left behind.

*~ By Eva Silverstein, Professor of Physics at Stanford University*

This is an excerpt from an article published in Quanta Magazine. You can read this story in its entirety here: *https://www.quantamagazine.org/joe-polchinski-physicist-who-developed-deep-ideas-and-paradoxes-dies-at-63-20180220/*

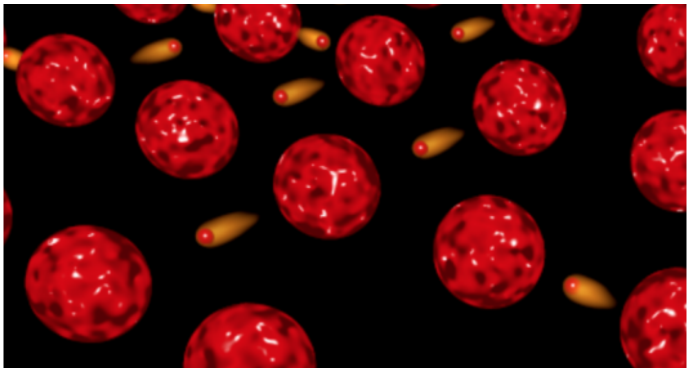


Eva Silverstein, Professor of physics at Stanford University

# Of Spins, Entanglements and Spooky Actions

## KITP permanent member Leon Balents is appointed to the Pat and Joe Yzurdiaga Chair in Theoretical Physics

To Leon Balents, a magnet is far more than the thing you stick on a refrigerator, or that odd mineral that attracts metal. What many of us perceive as just another way of displaying kids' artwork in the kitchen is to him a fascinating interplay of strong and weak atomic forces, gravity and of course, electromagnetism — the fundamental forces of the universe..



LEON BALENTS

A glimpse into the quantum world: A "strange metal" is envisioned as an array of quantum dots exchanging electrons.

Balents shared his fascination with a rapt crowd during his November 28, 2017 talk, "Magical Magnetism & Other Strange Stuff," the inaugural lecture of his appointment to the Pat and Joe Yzurdiaga Endowed Chair in Theoretical Physics. He is the second KITP faculty member to hold the position named for longtime campus supporters Joe and Pat Yzurdiaga. Balents follows in the footsteps of prominent string theorist Joe Polchinski who recently passed away.

In his opening remarks, KITP Director Lars Bildsten noted the lasting impact of Professor Balents mentoring of young scientists — both UCSB physics graduate students and KITP postdoctoral fellows: "There is always someone in Leon's office!"

"I love magnetism," Balents told the audience of family and friends, colleagues and supporters at his lecture. "Everyone has probably played with magnets as a kid; you can feel that mysterious force between them — it's like you can feel magic with your own hands."

The "magic" that we see and feel on the macroscopic level — ferromagnetism — is attributable to the collective behavior of electrons in the material, he explained, whose angular momentum, or "spin" causes each electron to behave like a magnet, with a positive and negative end.

"An electron is like a little bar magnet. You can think of it as a little spinning charge," Balents said, "and physicists know that a spinning charge makes a magnetic field, like a tiny electromagnet." Enough of these spins aligned in the same direction and you have a material that can call other, unpaired electrons of opposite alignment (typically from metals such as iron or copper) to themselves, or conversely, repel electrons of the same alignment.

Based on that fundamental electron spin behavior, one may expect more materials to be magnetic. In fact, said Balents, the mystery isn't so much why are only some things magnetic, but why isn't everything magnetic?

It turns out, he said, that while there are other, nonmagnetic materials that have electron spins, they don't create magnetic fields because their spins cancel each other out. Case in point: the antiferromagnet, whose existence was proven in 1949.

"Antiferromagnets actually come in a variety of forms; it's not just the simple up-down-up-down pattern," Balents said, describing the "up" or "down" state physicists use to characterize the spin of a subatomic particle. "There are all sorts of other patterns, and understanding what occurs in nature and how it occurs is kind of a tempting problem for theorists like myself."

Balents and colleagues are currently working on one such problem, in which applying a magnetic field to a certain crystal at different angles results in a peculiar "domain wall" — an area where the spins in one area of the crystal rotate from one direction to another. The net effect is still antiferromagnetic.

Diving deeper, things get spooky. In the subatomic quantum world, electron spins not only dictate the presence or absence of magnetism — they can connect so strongly that separating the electrons and keeping them at a distance does not affect their spins' correlations.

"That's a phenomenon that goes to the heart of quantum mechanics that's called entanglement," Balents said. "This separated pair of spins is called an Einstein-Podolsky-Rosen pair. What's weird about this is the state of either spin is completely undetermined." In fact, direct observation of spin states would actually collapse the system. However, whatever one electron's spin is — and in the simplest models it could be up, down or a superposition of both up and down — the other entangled electron's measurement will instantly correlate with it.

"You can ask the question Einstein did at the time: Where is this information stored, physically? It's not stored with either electron," Balents said. "It's stored somewhere completely different.

"It's called quantum nonlocality — information about the state of the physical system is not anywhere in a specific point in space," he said. "Einstein didn't really like this; he called it 'spukhafte Fernwirkung' — spooky action at a distance."

And yet, said Balents, quantum entanglement is far more common than one might suspect; nature actually forms these Einstein-Podalsky-Rosen pairs commonly between atoms and molecules. Some, including minerals called herbertsmithite and bismuth selenide, may look fairly mundane on the surface but in fact are massively entangled on the quantum level, he pointed out.

"So, we can imagine there are whole families of these strange states of matter," Balents said. And where entanglement exists, quasiparticles are usually not far away. Rather than being microscopically discrete particles, quasiparticles are states resulting from the collective interactions of particles such as electrons, which do a variety of things — including producing artificial light and creating magnetism — that physicists are still just beginning to explore.

According to Balents, the infinitesimal electron may one day provide clues to one of physics' biggest mysteries: gravity. While typically in the purview of astrophysicists — including many at KITP — who study enormous and exotic objects such as colliding black holes and neutron stars, gravity is expected to become a topic for those who study quantum systems as well.

"Two years ago, Alexei Kitaev suggested that studying a particular system of electrons — the quantum dot — exerting strong forces on one another, might lead to gravity," Balents said. It wouldn't be the gravity we experience in our three-dimensional space, he added, but the Caltech physicist's idea — recently outlined in a talk at KITP — has gained momentum at the institute and worldwide, charging hopes that understanding this type of quantum gravity might lead to insight on gravity in our reality.

"It's actually through the online access to this talk that most of the work following up on Kitaev's brilliant idea has occurred — it's probably one of the most accessed videos in KITP's massive archive of scientific talks," Balents said. "The field has grown so much that there will be an entire KITP program on the physics emerging from this idea for all of 2018."

Leon Balents is a theoretical physicist researching the quantum physics of materials. He received bachelor's degrees in physics and mathematics from MIT in 1989 and a Ph.D. in physics from Harvard in 1994. First coming to UCSB as a postdoctoral fellow in 1994, he returned in 1999 as a professor in the Department of Physics. Balents became a permanent member of KITP in 2008 and has received many honors and awards including recently being elected a member of the American Academy of Arts and Sciences.

*~ By Julie Cohen, Science Writer, UCSB Public Affairs*

# An Entanglement of Physicists

## An eclectic gathering at the KITP produces unexpected breakthroughs

What do a bucket of superfluid helium and a black hole have in common? How is the circuit board of a quantum computer related to Einstein's gravity equations? How can we use string theory to understand the behavior of a chunk of rock, cooled to near absolute zero? It is exactly this type of unorthodox mix of questions and ideas that can unexpectedly conjure up new breakthroughs. For the physicists who participated in the *"Entanglement in Strongly-Correlated Quantum Matter"* program at KITP in Spring 2015, such a breakthrough would be witnessed first-hand, manifest in a set of two talks given by the legendary Alexei Kitaev, then KITP Permanent Member, now professor at Caltech.

Alexei Kitaev

As its name suggests, the idea of quantum entanglement, once famously referred to by Einstein as "spooky action at a distance", was the focus of their efforts. Entanglement is the counter-intuitive, non-local correlation quintessential to quantum theory. It lies at the heart of the power of quantum computers, helping us understand and organize quantas of information. Increasingly, the concept of entanglement has been popping up in many disparate field of physics. Quantum computing, condensed matter, high energy, and gravity are all areas where physicists are re-tooling their theories to accommodate entanglement as a foundational idea.

One of the most exiting themes echoed in the corridors and scribbled on the blackboards of Kohn Hall was the apparent relationship between two completely different ideas. One, conformal field theory (CFT), is the theoretical structure of special types of phase transitions, present both in real matter, and in the quantum structure of space-time itself. The other, a type of classical gravity with negative (anti-de Sitter, AdS) curvature, was discovered recently to share exactly the same mathematical structure as a CFT, albeit in a higher dimension. This apparent "holographic" correspondence is particularly tantalizing to physicists, as it enables those on one side of the equation, say condensed matter theorists studying phase transitions in superfluid helium, to speak to those on the other side, say gravitational physicists whose purview is usually the realm of black hole horizons. A particular theme of this KITP program was the study of entanglement, on both sides of the correspondence, by men and women who previously thought their respective physics languages had long diverged, late in graduate school.

On April 7, 2015, a large crowd had gathered in the KITP auditorium, and Alexei took the stage for the first of his two chalkboard talks of the program. In the now famous online videos of the session, one can sense the quiet astonishment of the crowd as Alexei, in his typical modest and unassuming manner outlines how a certain model of randomly interacting electrons might lead, in a computable way, to an exact theory of gravity. A remarkable scene unfolds in slow-motion, as Alexei does what he does best, defining a simple model understandable to all physicists, which in this case gives a concrete example of the coveted AdS/CFT correspondence. His idea, a simple variant of a model introduced by Subir Sachdev and Jinwu Ye in 1993, has since this time been named the "SYK model", sparking a world-wide phenomena of intense study. It has raised many new questions on the nature of holography, and its relationship to quantum chaos, transport, and hydrodynamics. So influential is the idea that these two talks are already the most-watched in KITP's 29-year old online talks archive, with about 7,000 views to date.

While unique in its impact, Alexei's idea is exactly the type of breakthrough fostered by the KITP environment, where physicists from all walks and creeds gather to speak a common language, share ideas, and explore each others' fields. So rich is the new frontier sparked in 2015, that the KITP will host a new program in late 2018, entirely dedicated to the SYK model and the lessons that it is teaching physicists on the nature of reality and the interconnectedness of information, matter, and space-time. Like in the entanglement program that birthed it, it is hard to predict what will result from this new effort to bring physicists with a diverse range of tastes together under one roof. But if I've learned anything in the unique environment of the KITP, its that breakthroughs can happen in the blink of an eye.

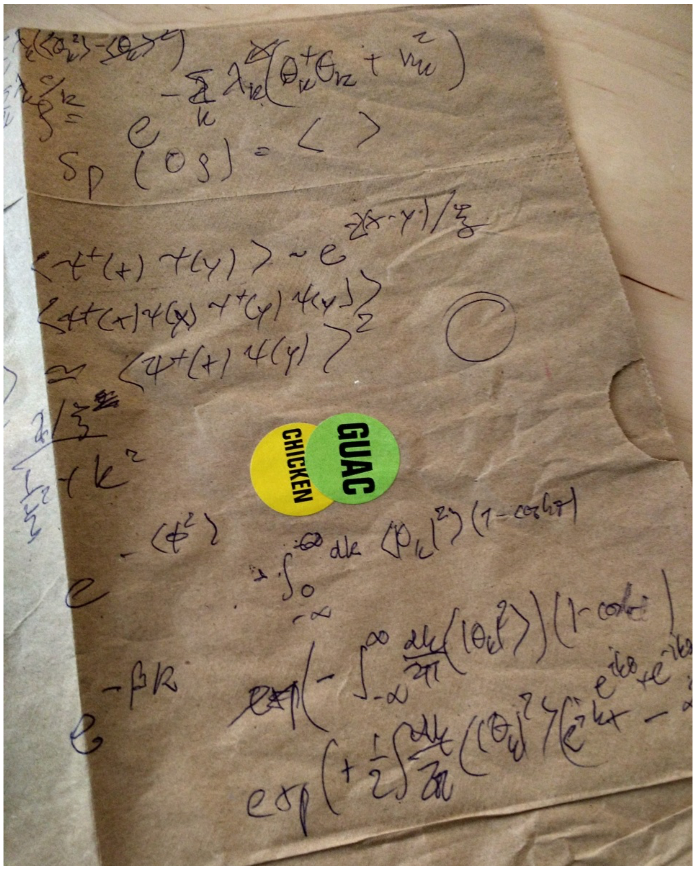
*~ By Roger Melko, Associate Professor, University of Waterloo*
*Associate Faculty, Perimeter Institute for Theoretical Physics*

MATT PERKO

KITP visiting scientists collaborating in the Tower Room at Kohn Hall Pictured from left to right: Sriram Ramaswamy, Indian Institute of Science; M. Cristina Marchetti, Syracuse University; Bulbul Chakraborty, Brandeis Univerisity; and Karin Dahmen, University of Illinois at Urbana Champaign

# From a Burrito Bag to Science Magazine

## It often takes a few years for KITP collaborations to yield




TIM LANGEN

On April 10, 2015 the journal Science published the report "Experimental observation of a generalized Gibbs ensemble" by Tim Langen and collaborators. This event, for the authors, was the culmination of a fruitful collaboration between their teams at the Technical University in Vienna, Austria, and the University of Heidelberg, Germany. As we know since the foundational work of Boltzmann, Gibbs, and many others, the kinetic motion of many molecules is conveniently described within a statistical approach in which the mean velocity of the atoms translates to the temperature of their ensemble. Many questions, though, on how the microscopic laws of quantum mechanics result in the well-known laws of statistical mechanics and thermodynamics, and thus in our classical world, still remain unanswered to date.

In their experiments, the team of Jörg Schmiedmayer in Vienna had managed to produce an exotic ensemble of about 5000 Rubidium atoms which, in a certain way, showed two temperatures at once. Starting with an elongated cloud at a temperature around 50 billionth of a Kelvin, forming a Bose-Einstein condensate, they managed to excite the motion of the particles in an intricate manner by suddenly splitting the electromagnetically trapped cloud into two almost identical halves. During the subsequent relaxation of the system it showed characteristics which could be interpreted in terms of a description which went beyond the standard equilibrium Gibbs ensemble of statistical mechanics. Such a "Generalized Gibbs Ensemble“ (GGE) had been proposed already in the late 1950s by Edwin T. Jaynes to be possible. Since it had been brought back into the scientific discussion by the work of Marcos Rigol and collaborators about a decade ago, this GGE has fascinated many physicists, in theory and experiment.

In the recollections of the theoretician and coauthor of the paper Thomas Gasenzer from Heidelberg, this collaborative project had in fact taken off on a sunny Sunday morning during the KITP program *"Quantum Dynamics in Far from Equilibrium Thermally Isolated Systems"* in late August 2012. On this morning he was walking from Goleta into downtown Santa Barbara when he realised, about halfway down the way, why a Bose condensate, suddenly split into two near-identical halves, instantly bears characteristics of a thermal equilibrium ensemble. Back at KITP he worked out, in a few lines, that the resulting ensemble looked thermal at very low energies while at the higher-energy end which should also be observable in an experiment, the gas properties deviate from being thermal and rather form what can be interpreted as a GGE. The derivations on the board in the bull-eyed octagon discussion room occured on the same day, after a first discussion with Langen and Schmiedmayer. Many intense discussions were to follow before the experimental data allowed to write a first draft over a year later. These discussions had started in Santa Barbara, and Tim Langen could even produce the chicken-guacamole burrito bag from his memorabilia collection containing some further theoretical insight gained during those days.

*~ By Thomas Gasenzer, Professor, University of Heidelberg*

MATT PERKO

WHITNEY FREEDMAN

KITP's Kohn Hall looking toward Goleta Beach and entrance to campus.

# Remembering Stephen Hawking

## Stephen Hawking, who died Mar. 14 — Albert Einstein's birthday and Pi Day — had a brilliant mind and a puckish sense of humor

From left to right, former UC Santa Barbara professor Andy Strominger (now at Harvard), Stephen Hawking and UC Santa Barbara's Gary Horowitz.

Gary Horowitz experienced it firsthand. Now a UC Santa Barbara physicist, Horowitz was a postdoctoral scholar when Hawking invited him to Cambridge for six weeks. At a social gathering, Horowitz recalled, Hawking was the life of the party, telling jokes and proffering puzzles for people to solve.

In a later visit to Cambridge, Horowitz saw up close Hawking's memory at work.

"Stephen was of course the Lucasian Professor of Physics, a chair held by Isaac Newton, and he was explaining this to me and he proceeded to say, 'Well I'm the current Lucasian Professor.' Then Stephen just proceeded over tea to recite and tell me every single Lucasian Professor of Physics back to Newton. He just knew them all."

Other UC Santa Barbara physicists who worked with Hawking also remember him for his sociability and recall, but, more importantly, for his keen insights into theoretical physics.

"It was the totality of the interactions with Stephen that was the important thing for me," said James Hartle, who worked with Hawking for decades. Among their many collaborations, the best known is a theory of the beginning of the universe. "Appreciating his keen insight into physics, the fact that he knew the right question to ask, the fact that he knew what to give up to provide an answer to that question, which was just as a hard as knowing the right question; his love of surprises."

"Stephen knew both what was the right question to ask and what's the thing to give up, like black holes aren't black," Hartle continued, in this case referring to Hawking's discovery that black holes can radiate and become smaller. "To have somebody like that — of course, it was a pleasure to work with him — you really make progress much faster than staggering around wondering."

Hawking's relationship with UC Santa Barbara was longstanding, beginning in the 1980s. For many years, he was a regular visitor to campus. In 1994, Hartle, then director of the campus' Institute for Theoretical Physics, launched a public lecture series to make physics accessible to a broad audience. Invited by Hartle to give the inaugural talk, Hawking did exactly that. He spoke to a capacity crowd at Campbell Hall.

TONY MASTRES

Stephen Hawking onstage at UC Santa Barbara's Campbell Hall in the 1990's. Hawking gave the inaugural KITP Public Lecture in 1994, filling the venue to capacity.

"We worked together on a number of different things, black holes and various ideas," Hartle said of Hawking. "But probably the main thing that we're known for is the quantum mechanical story at the beginning of the universe. Thanks to work by Stephen and Roger Penrose, the equations of classical physics are known to break down as you extrapolate them backward in time to the Big Bang. Something has to replace the classical equations there to have a complete theory of physics. Quantum mechanics is the likely culprit. But if the universe is a quantum mechanical system, it has a wave function. Stephen and I proposed one particular wave function of the universe, which agrees with the experiment and observations. That wave function is a theory of the beginning of the universe."

"Stephen's achievements were spectacular," Horowitz said. "His discovery of the black hole radiation has really dominated an area of theoretical physics for 40 years. It has raised very deep questions that we are still trying to answer."

DJAMEL RAMOUL

Stephen Hawking, front, at UC Santa Barbara in 2001, with, from left to right, Joseph Polchinski of UC Santa Barbara's Kavli Institute for Theoretical Physics (KITP), David Gross, currently UC Santa Barbara Chancellor's Chair in Theoretical Physics at KITP; Edward Witten, IAS, and Paul Steinhardt of Princeton University.

With an exchange program that brought Hawking's students to UC Santa Barbara and sent UC Santa Barbara students to study with his group at Cambridge, Hawking had a direct impact on the study of physics at the Santa Barbara campus.

"He added directly to the UC Santa Barbara physics experience and to the experience of our students and postdocs after they left UC Santa Barbara," said UC Santa Barbara physics department chair Don Marolf. "Hawking taught us all to keep our eye on the big picture and ask the big questions and try to look for full answers."

Added Horowitz: "I just think he's such an inspiration. He had all these hardships in life and he didn't give up or wallow in self-pity. He just kept pushing forward and doing what he wanted to do. He loved physics; he wanted to talk to physicists; he wanted to keep interactions. In addition to all the great insights he's given us, he's just been a great inspiration to keep going and pursue our dream of understanding nature."

*~ By Julie Cohen, Science Writer, UCSB Public Affairs*

# Breaking Science Barriers: How the Munger Residence Makes a Difference

The recent KITP Program *"Resurgent Asymptotics in Physics and Mathematics"* benefited greatly from the Charles T. Munger Physics Residence. Many participants had taken part in previous KITP Programs, staying in random housing locations scattered around town, and all were amazed by the many differences made by the simple fact that the participants now live under the same roof. The KITP Program experience has been totally transformed.

Even the seemingly mundane-sounding opportunity to discuss physics while walking together back and forth to KITP makes a huge difference. In addition, the various shared spaces at the Munger Residence, from BBQ to music, to snooker and ping-pong, provided many occasions for KITP scholars to get to know one another much better in an informal setting. This was particularly important in our Program, as we hosted a mix of physicists and mathematicians, from quite different fields, and who do not normally mix in conventional academic settings. It is much easier to ask questions over a dinner or a snooker table than it is during a seminar! Another important highlight was the ease with which participants with young families could attend the KITP Program. This is particularly important for young female scientists, and in our Program it was also crucial for several male participants. Indeed, in our program alone there were six key participants who would not have been able to take part if it had not been for the excellent family-friendly facilities at the Munger Residence. This fact was extremely important for the success of the Program. On a lighter note, we hosted two music nights, one of which was a well-attended concert, with some of our musically talented participants, also from the concurrent *"Physics of Quantum Information"* Program, and UCSB. These, and other, musicians also enjoyed the opportunity to practice and perform on the excellent pianos and guitars. In conclusion, thanks to Mr. Munger for a terrific development which has the KITP leading the way in yet another direction.

*~ By Gerald Dunne, Professor of Physics, University of Connecticut*







## 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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