IAS

Summer 2015

The Institute Letter

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A Larger Pattern of Institutional Racism

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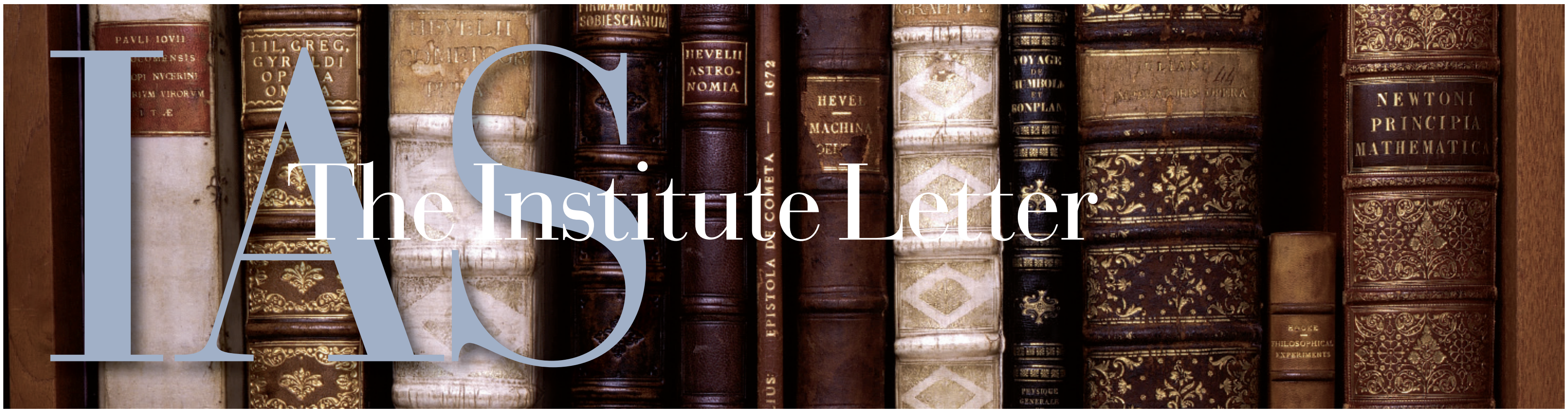

Institute for Advanced Study Summer 2015

Jonathan Haslam Appointed to Faculty

Studying contemporary phenomena in international relations

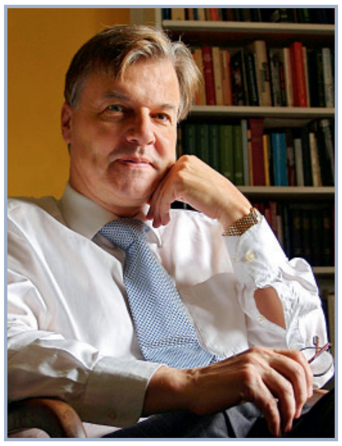

PHOTO COURTESY OF THE BRITISH ACADEMY

Jonathan Haslam

Jonathan Haslam, one of the world's most distinguished scholars on the history of thought in international relations, has been appointed George F. Kennan Professor in the School of Historical Studies. Haslam, a Member (1998) of the School, was most recently Professor of the History of International Relations at the University of Cambridge. He officially began his six-year appointment at the Institute on July 1.

The endowed Kennan Chair, established in 1995 to honor the diplomat, scholar, and Institute Faculty member George F. Kennan, was previously held by Avishai Margalit (2006–11), José Cutileiro (2001–04), and Jack F. Matlock, Jr. (1996–2001). The Kennan Chair is designed to bring to the Institute outstanding scholars whose work bears on the understanding of the contemporary world.

Haslam has made significant contributions to our understanding of contemporary phenomena in international relations through critical and prescient examinations of the role of ideology. Haslam's studies of Soviet foreign policy are expansive in their quality and range, demonstrating his keen originality of thought, supported by insightful and comprehensive archival research. This work solidified his reputation

(Continued on page 19)

A Larger Pattern of Institutional Racism

The multiple dimensions of state-sanctioned violence against black and brown youth

By Michael Hanchard

SCOTT OLSON/GETTY IMAGES

Protesting in Ferguson, Missouri, following the shooting death of teenager Michael Brown in 2014

I first met Emery Robinson at Albert Leonard Junior High School in New Rochelle, New York. He was two grades behind me, a seventh grader when I was in the ninth grade. He was known as a manchild, not only in terms of size, because he was much bigger than most ninth graders even then, but because he had the physicality and presence of a young man. He could have easily passed for seventeen or eighteen years old when, by my recollection, he could not have been much more than eleven or twelve.

His face, however, betrayed his youth; cherubic, at times shy, an easy laugh and mischievous smile, he was what one would refer to as "not a bad kid," to indicate someone who was a bit mischievous but not malicious. Because of his size he made the basketball team, though it did not seem as if he had a great interest in

(Continued on page 17)

Patricia Crone 1945–2015

The influential, pioneering scholar and her indelible mark on Islamic studies and the Institute

Patricia Crone, whose pioneering and innovative approach to the history of Islam brought about lasting change in the field, died at the age of 70 on July 11 in Princeton, New Jersey, after a courageous fight against cancer. She was Professor Emerita in the School of Historical Studies, where she served as the Andrew W. Mellon Professor since 1997, before retiring in 2014.

Crone's insightful work, compellingly conveyed in her adventurous and unconventional style, shed important new light on the critical importance of the Near East in historical studies, in particular on the cultural, religious, and intellectual history of Islam. Her influence is strongly felt at the Institute, where, along with Oleg Grabar (1929–2011), Crone helped to establish the Institute as a recognized center for the pursuit of the study of Islamic culture and history. Crone was succeeded in 2014 by Islamic intellectual historian Sabine Schmidtke, who is advancing important scholarship across Islamic culture and history.

Schmidtke noted, "Patricia's professional accomplishments, her publications, and their immense impact on the field speak to her exceptional value as a scholar. What made her even more exceptional as a person, however, was her caring and skill as a mentor. Patricia never hesitated to respond to a request for help from a fellow scholar, including not only those who were already well on their way in their academic careers, but many who were just starting out and needed access to her writings. Patricia never ignored such requests—and there were many—but handled them all with her characteristic 'Patricia style,' sometimes offering what might be seen as 'tough love,' but always in a quiet and private way, with a directness and honesty that was a turning point for many in their lives and careers. Her skill as a caring mentor is an equally important legacy to all of her other accomplishments."

Nicola Di Cosmo, Luce Foundation Professor in East Asian Studies in the School of Historical Studies, added, "For nearly four decades, Patricia's work on Islam has been a brilliant example of fiercely creative, deeply probing, and unfailingly farsighted research. She pushed the boundaries of historical knowledge and imagination, and in so doing defied accepted wisdom and opened doors to hidden truths. With her passing we lose a most lucid interpreter of fundamental historical questions."

CLIFF MOORE

Patricia Crone

"Patricia was a marvel of high spirit and determination, and was absolutely fearless, both in her professional and in her personal life—a wonderful inspiration for us all," stated Robbert Dijkgraaf, Director of the Institute and Leon Levy Professor. "She will be greatly missed here at the Institute,

(Continued on page 18)

A series of anthropological essays examining the politics of lives, of bodies, and of morals, *Ripoliticizzare il mondo* (2014) by DIDIER FASSIN, James D. Wolfensohn Professor in the School of Social Science, has been published by Ombre Corte. Additionally, Éditions du Seuil has published *L'Ombre du monde: Une anthropologie de la condition carcérale* (2015), the result of Fassin's four-year ethnographic study of day-to-day aspects of life in prison and the politics of punishment.

PETER SARNAK, Professor in the School of Mathematics, has received an honorary Doctor of Science degree from the University of Chicago.

Brill has published a collection of articles, *The Yemeni Manuscript Tradition* (2015), edited by David Hollenberg, Christoph Rauch, and SABINE SCHMIDTKE, Professor in the School of Historical Studies. Additionally, Schmidtke was named a member of the jury of the 2016 Gerda Henkel Prize, which is awarded every two years by the Gerda Henkel Foundation.

Post-Planck Cosmology: Lecture Notes of the Les Houches Summer School (2015), edited by Cedric Deffayet, Patrick Peter, Benjamin Wandelt, Leticia F. Cugliandolo, and MATIAS ZALDARRIAGA, Professor in the School of Natural Sciences, has been published by Oxford University Press.

CAROLINE WALKER BYNUM, Professor Emerita in the School of Historical Studies, has received an honorary doctorate from The Hebrew University of Jerusalem.

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Questions and comments regarding the *Institute Letter* should be directed to Kelly Devine Thomas, Editorial Director, via email at kdthomas@ias.edu or by telephone at (609) 734-8091.

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The New York Review of Books has published *Dreams of Earth and Sky* (2015), a collection of essays written by FREEMAN DYSON, Professor Emeritus in the School of Natural Sciences, on topics such as physicists Richard Feynman, J. Robert Oppenheimer, and Paul Dirac; scientific revolutions; the flood of information in the digital age; and the future of biotechnology.

Yale University Press has published *The Paradox of Liberation: Secular Revolutions and Religious Counterrevolutions* (2015) by MICHAEL WALZER, Professor Emeritus in the School of Social Science, which seeks to understand why the newly independent nations of India, Israel, and Algeria have been sharply attacked by different groups of religious revivalists.

CORINNE BONNET, Member (2009) in the School of Historical Studies, has received the Prix Franz Cumont from the Royal Academy of Belgium for her book *Les enfants de Cadmos: Le paysage religieux de la Phénicie hellénistique* (Éditions de Boccard, 2014).

GARTH L. FOWDEN, Member (1990–91) in the School of Historical Studies, has been elected a Fellow of the British Academy.

MAURO F. GUILLÉN, Member (1998–99) in the School of Social Science, has been appointed Trustee of the Fundación Princesa de Asturias, the royal foundation of Spain.

Members in the School of Social Science LAURENCE A. RALPH (2012–13) and THOMAS J. SUGRUE (2005–06) have been selected by the Carnegie Corporation of New York as Andrew Carnegie Fellows for research that addresses urgent contemporary issues from fresh perspectives.

CLAUDIA RAPP, Member (1997–98) in the School of Historical Studies, has received the 2015 Ludwig Wittgenstein Prize from the Austrian government.

CATHERINE ROTTENBERG, Visitor (2012–13) in the School of Social Science, has received the 2015 Claire Goldberg Moses Award for "Happiness and the Liberal Imagination: How Superwoman Became Balanced," the most theoretically innovative article of the year published in the journal *Feminist Studies*.

SARA SEAGER, Member (1999–2002) in the School of Natural Sciences, has been elected to the National Academy of Sciences.

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Imagination, Knowledge, and a Record-Setting Campaign

To celebrate the successful completion of the Campaign for the Institute on June 30, artist Mark Podwal created an image (above and on the cover) inspired by a quote by Albert Einstein, one of the Institute's first Professors, "Imagination is more important than knowledge." The image shows the IAS seal and its classical figures of Truth and Beauty (center) as if created by (clockwise from upper left) Salvador Dalí, Pablo Picasso, Sandro Botticelli, Fernand Léger, and Henri Matisse.

Propelled by the extraordinary $100 million challenge grant of Trustee leaders Jim Simons and Charles Simonyi, launched on January 1, 2011, an additional $112 million in support was raised over the last four-and-a-half years. In addition to the outstanding support provided by the Institute's Board of Trustees, record-setting contributions were received from current and former Members, Friends of the Institute, foundations, Faculty, and Staff. More than 1,600 supporters residing in 38 countries, with more than 800 new donors among them, participated in this momentous achievement.

The total $212 million given during the course of the Campaign strengthens IAS in a variety of ways. Some $149 million will be added to the IAS endowment, creating three new endowed Professorships and twelve new Membership endowments. Among these are the recently established Bezos Membership in Astrophysics in the School of Natural Sciences, endowed by former Trustee Jeff Bezos, and the Shiing-Shen Chern Membership in the School of Mathematics in honor of Chern's fundamental contributions to the field of mathematics and his connection to IAS as a frequent Member beginning in 1943 through 1964. Equally essential, $43 million provides for the current operations of the Institute, greatly renewing IAS's financial resources and its impact as an international leader of curiosity-driven research. ■

John Forbes Nash, Jr., 1928–2015

In his 1994 Nobel Prize biographical essay, John Nash introduces himself: "My beginning as a legally recognized individual occurred on June 13, 1928, in Bluefield, West Virginia . . ." His father was an electrical engineer and his mother was a school teacher before marriage. Bluefield, a small city in the Appalachians, was described by Nash as "not a community of scholars or of high technology." As a child, he learned from reading *Compton's Pictured Encyclopedia*, and by the time he was a student in high school, he was reading the classic *Men of Mathematics*, written by E. T. Bell in 1937. Below is an excerpt from Bell's introduction to the volume, which Nash described as "very impressive—it gives you sort of a romantic impression of some of the mathematicians, the great minds."

Of recent years there has been a tremendous surge of general interest in science, particularly physical science, and its bearing on our rapidly changing philosophical outlook on the universe. Numerous excellent accounts of current advances in science, written in as untechnical language as possible, have served to lessen the gap between the professional scientist and those who must make their livings at something other than science. In many of these expositions, especially those concerned with relativity and the modem quantum theory, names occur with which the general reader cannot be expected to be familiar—Gauss, Cayley, Riemann, and Hermite, for instance. With a knowledge of who these men were, their part in preparing for the explosive growth of physical science since 1900, and an appreciation of their rich personalities, the magnificent achievements of science fall into a truer perspective and take on a new significance.

The great mathematicians have played a part in the evolution of scientific and philosophic thought comparable to that of the philosophers and scientists themselves. To portray the leading features of that part through the lives of master mathematicians, presented against a background of some of the dominant problems of their times, is the purpose of the following chapters. The emphasis is wholly on modern mathematics, that is, on those great and simple guiding ideas of mathematical thought that are still of vital importance in living, creative science and mathematics.

It must not be imagined that the sole function of mathematics—"the handmaiden of the sciences"—is to serve science. Mathematics has also been called "the Queen of the Sciences." If occasionally the Queen has seemed to beg from the sciences she has been a very proud sort of beggar, neither asking nor accepting favors from any of her more affluent sister sciences. What she gets she pays for. Mathematics has a light and wisdom of its own, above any possible application to science, and it will richly reward any intelligent human being to catch a glimpse of what mathematics means to itself. This is not the old doctrine of art for art's sake; it is art for humanity's sake. After all, the whole purpose of science is not technology—God knows we have gadgets enough already; science also explores depths of a universe that will never, by any stretch of the imagination, be visited by human beings or affect our material existence. So we shall attend also to some of the things which the great mathematicians have considered worthy of loving understanding for their intrinsic beauty.

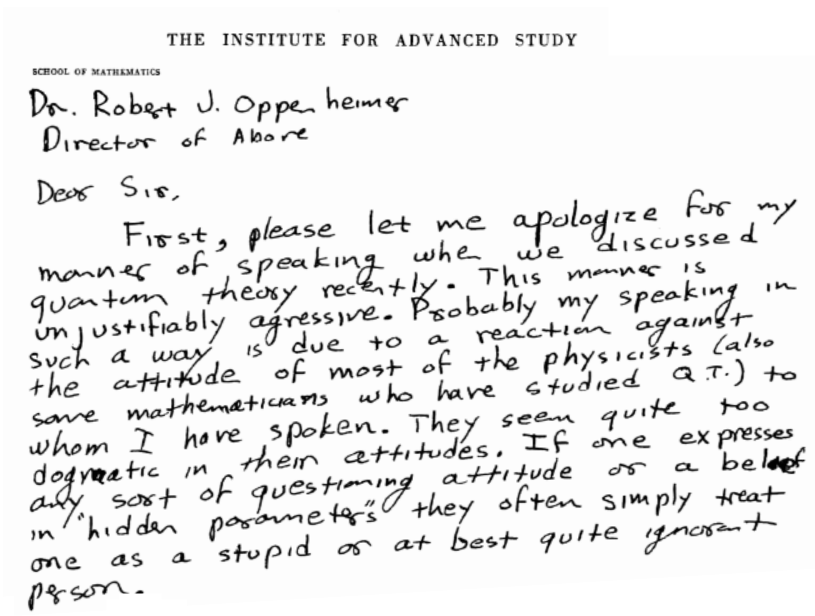
SERGE J-F. LEVY

John Nash, reading in the Fuld Hall Commons (2011)

On May 19, 2015, King Harald V of Norway presented the Abel Prize from the Norwegian Academy of Science and Letters to John Forbes Nash, Jr., Member (1956–57, 1961–62, 1963–64) in the School of Mathematics, and long-time member of the Princeton University Department of Mathematics, for his contributions to the theory of nonlinear partial differential equations, which are used to describe the basic laws of phenomena in physics, chemistry, biology, and other sciences. Returning to Princeton from the prize ceremony in Oslo, Nash and his wife Alicia died together in an automobile accident. "I hope one thing will become clear when we look back on Dr. John Nash's life," observed Robbert Dijkgraaf, Director of the Institute and Leon Levy Professor. "There are many brilliant minds, but he was a very special kind. . . . He was always going in directions that were either thought to be impossible, or actively discouraged."

One of a handful of mathematicians known outside academia—due to the film based loosely on the biography A Beautiful Mind *(Simon & Schuster, 1998) by Sylvia Nasar, written during her time as a Director's Visitor at the Institute—Nash's early brilliance and later acclaim were contrasted by decades of mental illness and relative obscurity. International recognition came in October 1994 when Nash, after attending an Institute seminar, had a conversation with mathematician Harold Kuhn. "As we sat on the bench, enjoying the mild fall weather and the splendor of the Institute woods, I told John that he should be up at 6:30 a.m. the following morning to receive a phone call from Carl-Olof Jacobsen, Secretary General of the Nobel Foundation, who would tell him that he was sharing the Prize in Economic Sciences in Memory of Alfred Nobel," recalled Kuhn in the preface to* The Essential John Nash *(Princeton University Press, 2002).*

Nash married Alicia during his first visit as a Member in 1956–57. Then twenty-nine years old, he wrote the following letter (from the Institute's Shelby White and Leon Levy Archives Center) to J. Robert Oppenheimer, the Institute's Director from 1947–66.



THE INSTITUTE FOR ADVANCED STUDY
SCHOOL OF MATHEMATICS

Dr. Robert J. Oppenheimer
Director of Above

Dear Sir,

First, please let me apologize for my manner of speaking whe we discussed quantum theory recently. This manner is unjustifiably agressive. Probably my speaking in such a way is due to a reaction against the attitude of most of the physicists (also some mathematicians who have studied Q.T.) to whom I have spoken. They seem quite too dogmatic in their attitudes. If one expresses any sort of questioning attitude or a belief in "hidden parameters" they often simply treat one as a stupid or at best quite ignorant person.

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Second, let me thank you (also speaking for Alicia) for the invitation to the Spring Dance. This was a very pleasant affair and the food served afterwards was especially nice and suitable.

Now I am making a concentrated study of Heisenberg's original 1925 paper "Über quantentheoretische Umdeutung kinematischer und mechanischer Beziehungen." This strikes me as a beautiful work and I am amazed at the great difference between expositions of "matrix mechanics," a difference, which from my viewpoint, seems definitely in favor of the original.

There is general phenomenon, affecting mathematics, and physics (I am particularly familiar with the mathematics situation) of evolutionary elegantizing camouflage. A creative man will carry through a successful endeavor, perhaps developing a new theory. In original form the connections to the prior body of knowledge and the path by which he moved may still be visible or inferable (of course the whole of his preliminary work and ideas never shows). Later the theory is generalized. New notations are introduced, conceptual patterns are built up. Elegance is introduced, at the cost of clarity, if necessary. The success of the theory makes it no longer necessary to give an exposition revealing its relations to, and outgrowth from, the more primitive theory of the past. Now it can be presented as dogma.

To me one of the best things about the Heisenberg paper is its restriction to the observable quantities. I feel the current standard formulations of Q.M. have lost this quality to a considerable extent. Of course I want to find a different and more satisfying under-picture of a non-observable reality (at least non-observable directly through standard electromagnetic [atomic] interactions, which always disturb the system uncontrollably and give rise to the uncertainty principle).

In this 1925 paper Heisenberg's theory still has the character that Bohr's had (although more subtly) of being an adjunction of modifying rules to the classical theory of a mechanical system or atom. The drastic character of the revolution is susceptible to exaggeration. This quality also appears in subsequent formulations because of the usability of the Hamiltonian.

I want to discover why the classical picture is still latent in Q.M. to such a strong extent. Of course this is an individual matter of opinion and feeling. Only the individual himself can finally decide that he considers that he understands something.

Perhaps when I have carried my study and thinking further I will be in a better position to carry on a fruitful discussion with others who are versed on the subject.

Before closing let me thank you again for the sacrifice of your time and apologize for my annoyance. The conversations have actually been quite stimulating and helpful to me.

Sincerely yours,
John Nash

Recommended Reading and Viewing:

"What John Nash Taught Us," Robbert Dijkgraaf, *Time* (May 24, 2015): http://time.com/3895322/john-nash

Abel Prize committee's short film about Nash and his work: www.abelprisen.no/artikkel/vis.html?tid=63683.

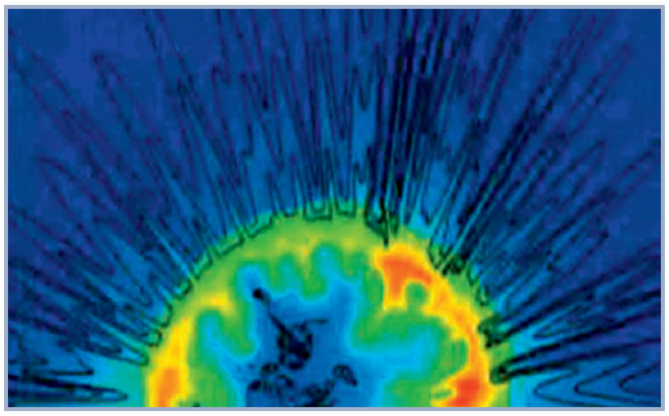
How Do You Know a Nuclear Weapon Works if You Can't Test It?

And what would an anthropologist know about that?

BY HUGH GUSTERSON

In 1987, in my third year as a graduate student in anthropology, I arrived in the small California town of Livermore, host to one of two nuclear weapons design laboratories in the United States. Thanks to an indulgent dissertation committee, which had allowed me to abandon my original goal of doing fieldwork in Africa for a much more unconventional project, I came to Livermore intent on understanding the culture of the scientists, mainly physicists, who worked on the most powerful weapons on Earth. The anthropology of science did not yet exist as a recognized sub-field of anthropology but, in retrospect, that is what I was doing.

I came to Livermore at a moment when the nuclear weapons labs at Livermore and Los Alamos were on the defensive. The nuclear freeze campaign of the early 1980s had had some success in reframing the nuclear arms race as a danger to, not a guarantor of, security. "End the race or end the race," as their slogan went. In 1982, more than a thousand protestors were arrested for civil disobedience at the gates of the Livermore Laboratory. Then, in 1985, the new Soviet leader, Mikhail Gorbachev, suspended Soviet nuclear testing for eighteen months, challenging the United States to join him. And at the Reykjavik Summit of 1986, Ronald Reagan and Mikhail Gorbachev astonished the world by coming close to an agreement to abolish nuclear weapons.



LAWRENCE LIVERMORE NATIONAL LABORATORY

Under the Stockpile Stewardship program, laboratories like Livermore obtained some of the most powerful supercomputers in the world on which they could simulate nuclear tests.

In this context, there was mounting pressure to end nuclear testing. No arms control measure could have been more damaging to the Livermore Laboratory since its main product was not nuclear weapons but nuclear tests. (After a round of tests fixed the final design, the weapons were manufactured elsewhere.) The Laboratory argued that continued nuclear testing was imperative since it would be impossible to be sure that aging nuclear weapons were reliable if they could not be tested. The one public dissenter within the Laboratory was Ray Kidder, a veteran weapons designer and pioneer of laser fusion, who wrote a report for Congress arguing that stockpile reliability could be assured through the judgment of experienced designers and the remanufacture of weapons as they aged out.

The debate was simultaneously political and technical, and the weapons laboratories won it in the late 1980s, when I was doing my fieldwork. But the political momentum for nuclear testing weakened when the Cold War ended in 1989 and the Soviet Union fell apart in 1991. There was no longer a need for new nuclear weapons, and many countries without nuclear weapons were now pressing the nuclear powers to end testing as a way of honoring their 1970 pledge of "cessation of the nuclear arms race at an early date" in Article VI of the Nonproliferation Treaty. As I became an assistant professor in 1992, the George H. W. Bush administration was maneuvered into signing off, reluctantly, on a moratorium on nuclear testing cosponsored by Republican Senator Mark Hatfield. He cunningly attached the moratorium to the funding bill for the Superconducting Supercollider in Texas, which President Bush believed he needed in order to carry Texas in the 1992 presidential election. (In the end, he lost both Texas and the election, as well as nuclear testing.)

The moratorium allowed up to fifteen nuclear tests to optimize the stockpile for a permanent ban on nuclear testing. Bill Clinton's Secretary of Energy Hazel O'Leary worried that the fifteen tests would prove a backdoor into a permanent resumption of nuclear testing. She convened a two-day meeting in Washington, D.C., May 17–18, 1993, to which she invited the directors of the weapons labs and their key scientific advisers to make their case that more tests were needed to assure the reliability of the stockpile. They brought with them a full-size mock-up of a nuclear weapon sliced in half so they could give the new secretary a tutorial on weapons design. To the lab directors' consternation, O'Leary also invited three leading physicists who were advocates of a test ban to argue it out with the managers of the weapons labs while she watched. The three independent physicists were Ray Kidder of Livermore; Sid Drell, the former Director of the Stanford Linear Accelerator Center (and currently Institute Trustee Emeritus); and Frank von Hippel of Princeton, who was rushed a security clearance in one day so he could attend. I have interviewed ten people who were at that meeting, including the secretary of energy herself. The accounts diverge in interesting ways, but all agree that the meeting went badly for the lab directors. Finally, in the afternoon of the second day, one of the directors volunteered that the weapons labs could find a way to keep the stockpile reliable if they were given the same resources not to test as they had enjoyed when they did test.

Thus, U.S. nuclear testing was ended for good and a program called Stockpile Stewardship was born. The budget for the Stockpile Stewardship program was initially $4.5 billion a year, but has now grown to over $8 billion a year. Under this program, the most powerful laser in the world, the National Ignition Facility, was built at Livermore; a device for exploring the implosion dynamics of nuclear weapons, the Dual-Axis Radiographic Hydrodynamic Test Facility, was built at Los Alamos; a pulsed power facility, the Z machine, was built at Sandia, the engineering support laboratory for Livermore and Sandia; Livermore and Los Alamos were allowed to keep using the Nevada Nuclear Test Site for underground experiments with plutonium that stopped short of a nuclear explosion; and the laboratories obtained some of the most powerful supercomputers in the world on which they could simulate nuclear tests. This set of experimental and computing facilities has enabled the weapons labs to better understand the basic physics of nuclear weapons, and to recruit and train a new generation of nuclear weapons scientists. Senior managers at Livermore and Los Alamos have explained to me in numerous interviews over the years that, in the final analysis, the reliability of the stockpile rests on the expert judgment of American nuclear weapons scientists, and that stockpile stewardship offers a way to build and test that judgment in the way that nuclear testing did in a previous era.

Interestingly, that line of argument has been contested by … Ray Kidder. (Kidder has been joined in his critique by Richard Garwin, an influential physicist who has consulted for the nuclear weapons programs for years.) When Kidder argued for an end to nuclear testing in 1992, he envisaged a new set of arrangements, more like the approach the Russians would adopt, in which aging nuclear weapons would be replaced by identical copies that hewed to tried and tested designs. Instead, under the stewardship program, aging weapons evolve as they are refurbished under the supervision of weapons scientists whose judgment is said to guarantee their continuing reliability.

The last time I went to Livermore, the weapons designers I spoke to said they had great confidence in the reliability of the stockpile based on the convergence of stockpile stewardship experiments and supercomputer codes, and on high levels of intersubjective agreement among weapons designers. As I got a tour of the National Ignition Facility, I noticed a big banner that said "stockpile stewardship is working!" But how do we know? And what might an anthropologist contribute to an understanding of these issues?

Anthropologists who study scientists sometimes foreground the social implications of scientific controversies that may be less apparent to scientists inside those controversies, or they might ask why a debate is framed in a particular way, or they might commit to writing concerns confided quietly to an anthropologist that scientists are reluctant to voice in public. In my writing about Livermore, I have been struck by the agility with which one of the largest scientific institutions in the world could adapt to losing its central experimental practice—nuclear testing—and by the way it was able to move in a single decade from insisting that nuclear testing was essential to demonstrating the reliability of nuclear weapons to saying it was not, building an internal staff consensus around a 180-degree shift in position. I have also argued that during the Cold War, nuclear testing was not just a way of securing scientific and technical claims, but also an essential mechanism for regulating social hierarchies within the laboratory where people were tested as much as weapons and where testing was the locus of apprenticeship. Through stockpile stewardship, Livermore has found new modes of apprenticeship and new ways of establishing hierarchies of expert judgment within the laboratory.

In the end, I keep coming back to the question of how you know a weapon works if you cannot test it. (Or, for that matter, how testing ever established reliability since it destroyed the object whose reliability it demonstrated.) Who am I to question the judgment of the physicists who have spent decades honing their expert knowledge of this arcane field? Still, I keep thinking of a conversation I had in 1995 with a senior weapons designer, now retired, who told me that an inexperienced designer with a code is like a drunk driver, wrongly convinced of their excellent judgment. And I cannot help but notice a 2012 Department of Energy report complaining that National Ignition Facility shots were not producing the energy levels predicted by simulation codes. Nor, in 2015, has the National Ignition Facility met its former director's prediction of reaching ignition—getting more energy out than was put in—by late 2012.

But maybe, as my Institute colleagues reminded me when I spoke on these matters in an After Hours talk, what really matters is not whether a nuclear weapon really works but whether we believe it does. ■

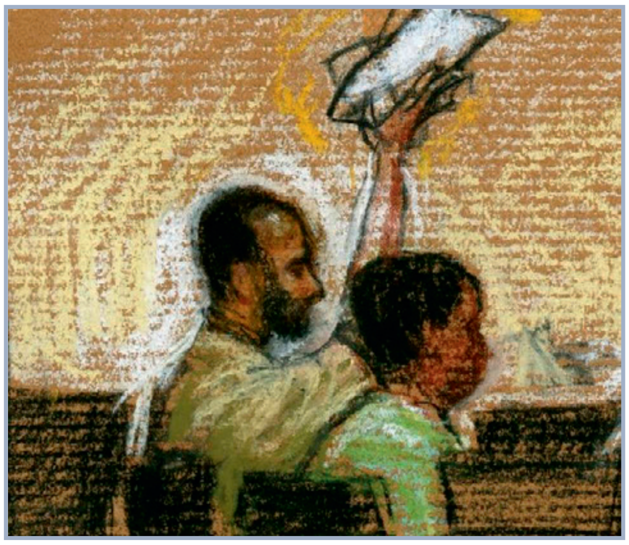
Hugh Gusterson, Member (2014–15) in the School of Social Science, is Professor of Anthropology and International Affairs at George Washington University. He is author of two books on nuclear weapons scientists: Nuclear Rites *(University of California Press, 1996) and* People of the Bomb *(University of Minnesota Press, 2004).*

Does Propaganda Incite Violence?

Understanding the effects of hate speech

BY RICHARD ASHBY WILSON AND CHRISTINE LILLIE

Over the last ten years, national and international courts have prosecuted a greater number of political leaders and their propagandists who incite others to commit acts of war, terrorism, and genocide. The United States government, a self-avowed promoter of freedom of speech, has pursued al-Qaeda propagandists such as Ali al-Bahlul and Sulaiman Abu Ghaith, and in 2014 a federal court sentenced Ghaith to life in prison for what his defense attorney called "just talk." The International Criminal Tribunal for Rwanda has convicted eight defendants, including radio broadcasters and a Rwandan pop star, of direct and public incitement to commit genocide. Combatting election propaganda is a priority of the International Criminal Court's chief prosecutor, Fatou Bensouda, who warned in advance of the recent Nigerian elections that "any person who incites or engages in acts of violence by ordering, requesting, encouraging, or contributing in any other manner to the commission of crimes … is liable to prosecution either by Nigerian courts or by ICC."



SKETCH POOL/THE MIAMI HERALD

Ali al-Bahlul waves a sign, "Boycott," printed in Arabic and English, during his arraignment for war crimes related to his work as al-Qaeda media secretary.

Intuitively, we may feel that leaders and media figures who incite genocide and crimes against humanity should bear criminal responsibility. Yet there does not exist any conclusive body of social science evidence demonstrating that extreme speech directly influences attitudes and behavior. Anthropologists and political scientists interviewed hundreds of convicted perpetrators of the 1994 genocide in Rwanda, and they reported that peer pressure from male neighbors and kin influenced their decisions to participate in genocide more than government and radio propaganda. Of course, listeners are not always consciously aware of their motivations, and quantitative approaches have yielded divergent findings that identify the harmful effects of hate speech. Economist David Yanagizawa-Drott used an econometric analysis of prosecution rates and radio coverage and found that approximately ten percent of the participation in the Rwandan genocide can be attributed to radio broadcasts, corresponding to an estimated 50,000 murders.

These mixed findings justify the use of other social science methods to understand the phenomenon of inciting propaganda. We designed psychological and physiological studies to test the concrete effects of propaganda, drawing on the actual speeches of Vojislav Šešelj, a Serb political leader presently awaiting judgment in The Hague for instigating murder, torture, and deportation of Croat civilians in the early 1990s. Šešelj is not charged with committing material acts of murder or deportation, but the prosecution alleges that over nine hundred people died as a result of his public calls for the persecution of other ethnic groups. We obtained 242 of his public speeches during the time period of the indictment and coded them into eight sub-categories: calls for revenge, extreme nationalist sentiments, negative stereotyping of other groups, dehumanizing language, demands for justice, references to past atrocities, victimization of his own group, and warnings of a direct threat to his group.

As with much war propaganda, two of the most frequent types of speech Šešelj used were dehumanizing language and calls for revenge. Dehumanizing speeches referred to Croats as animals devoid of human qualities, for example: "We, Serbs, as a people, let a poisonous snake bite our heart three times after holding it in our arms. That poisonous snake, that's the Croats…. Now we need to smash its head so it never bites anyone again." The revenge speeches called for retribution on behalf of past victims: "But, if the Croats try to massacre us, the Serbs will not forgive nor forget. Our revenge will be horrific.… Those who survived have no right to forgive in the name of the slaughtered."

Over four hundred participants from the United States read either one of the propagandistic speeches or a control speech. Subsequently, they were asked questions about their empathy for the in-group and the out-group, their perceptions of the intentions of the in-group and the out-group, and whether violence is ever morally justifiable. Some of the results we anticipated. All of the types of speech, with the exception of nationalism, reduced the propensity of the participants to empathize with the out-group. Nationalism, revenge, and warnings of a direct threat raised empathy levels for the in-group. Nationalism, revenge, negative stereotyping, dehumanization, and references to justice systems all elevated positive attitudes toward the in-group.

Other results were unexpected. Only revenge speech increased overall negative attitudes toward the out-group. Significantly, only the speeches that called for revenge and that referenced past atrocities led the participants to morally justify violence. Not only did revenge speech increase moral justifications of violence, but it also consolidated in-group identity to the same extent as highly nationalistic rhetoric. Dehumanizing speech, generally seen by criminal courts and experts as the most extreme form of hate speech, did not have the same effect on participants' willingness to justify violence. Intriguingly, dehumanization speech increased participants' belief that the aggressors are morally responsible for their acts, while revenge speech had exactly the opposite effect—they were judged as not morally responsible. We theorize that revenge speech disposes people to view the opposing group as lacking in any moral capacity, i.e., no longer made up of cognizant individuals capable of moral thought. This may explain intercommunal violence where aggressors turn against neighbors and colleagues with whom they had previously enjoyed close social bonds.

At the personality level, those who believe the world is not a just place, are more politically conservative, and engage more in violent media are more predisposed to justify violence. Male participants were more susceptible to the effects of propaganda than females. Further research is needed, as we were not able to examine the interactions among different types of speeches, nor were we able to ascertain the effects of repetition, one of the hallmarks of propaganda. We have just conducted the survey in Belgrade, Serbia, and are presently analyzing the similarities and differences between the U.S. and Serbian populations' responses to inciting speech. The results of this comparison will provide insights into some of the variations between political communities that have distinct public cultures and histories of armed conflict.

The next question is, what is the mechanism through which denigrating and inciting speech influences the listener? We followed up our psychological study with a physiological experiment using facial electromyography, which measures emotional reactions through facial muscle activity. We utilized only the revenge and dehumanization speeches, and we expected that revenge speech would elicit anger and the dehumanization speech would elicit disgust, but our expectations were confounded. In response to the speeches calling for revenge, our participants showed physiological indicators of disgust rather than anger. Neither disgust nor anger registered in response to speech that dehumanized the out-group. This suggests that the response of "moral disgust" is central to understanding how revenge speech affects empathy and enhances justifications of violence.

What do these findings mean for the criminalization of propaganda for terrorist and extreme nationalist causes? First of all, the results tell us that propaganda has demonstrable conditioning effects that lead to greater in-group solidarity and opposition towards the out-group, as well as inculcating a greater tolerance toward violence against another population. These general findings do not determine whether a specific individual speaker incited particular listeners to commit certain crimes. However, they do indicate that certain types of speech will have probabilistic effects on a proportion of listeners. Specifically, they tell us that revenge speech is more likely to lead to violence than other forms of speech. Previous international criminal courts, as well as social scientists, have emphasized the role of dehumanizing propaganda during genocide; however, our results suggest that dehumanization may not be the most egregious form of inciting speech. Rather, prosecutors at international tribunals may be able to construct a more compelling case against political leaders inciting violence on the basis of revenge, since the causal link to subsequent violence is better supported by the evidence. Prevention of genocide has always been a weakness of the international system, and our findings could guide prosecutors regarding whom to indict, and when to indict, as part of a wider effort to forestall mass atrocities.

Ultimately, it is up to the courts to decide how they will judge the zealous advocates and recruiters for extreme and violent causes. The social science of inciting speech, however, is becoming more conclusive and may contribute to evidence-based policy-making at the national and international levels. It points toward the negative and damaging effects of revenge speech and can guide policy-makers and international prosecutors who attempt to restrain the propagandists of discriminatory hatred and violence. ■

Richard A. Wilson, Friends of the Institute for Advanced Study Member (2014–15) in the School of Social Science and Gladstein Professor at the University of Connecticut School of Law, studies the effects of denigrating speech. Christine Lillie is a postdoctoral fellow at Duke University in the Department of Psychology & Neuroscience and the Kenan Institute for Ethics. Their full paper may be accessed at http://bit.ly/1EjV8rA.

Studying Graffiti in an Ancient City: The Case of Aphrodisias

Children of the night, products of conflict, and media of slander

BY ANGELOS CHANIOTIS

During Augustus's reign (late first century B.C.E.), the philosopher Athenodoros returned from Rome to his hometown Tarsos, in southwest Turkey. When he found the city dominated by the poet and demagogue Boethos, he used the authority given to him by Augustus to send Boethos and his followers into exile. Thereupon, Boethos's partisans

> wrote against him on the walls: "Deeds are for the young, counsels for the middle-aged, but farts for the old men." When Athenodoros took the inscription as a joke, he ordered to add "thunders for old men." But then someone, who despised all decency and had a loose belly, came in the night to his house and profusely bespattered the door and the wall. When Athenodoros brought accusations in the assembly against that faction, he said: "One may recognize the city's illness and disaffection in many ways, and in particular from its excrement."

This incident, narrated by the geographer Strabo,[1] is one of the few references of ancient authors to graffiti. Another one is found in the *Courtesans' Dialogues* composed by the satirist Lucian in the second half of the second century C.E. Two prostitutes, Drosis ("fresh as dew") and Chelidonion ("the little sparrow"), discuss possible strategies against the philosopher Aristainetos, who was preventing Drosis's lover, Kleinias, from visiting her. Chelidonion volunteers to help in a slander campaign: "I think that I will write on the wall in Kerameikos 'Aristainetos is corrupting Kleinias.'" When Drosis wonders how Chelidonion can do this without being seen, her friend responds: "By night, Drosis, taking charcoal from somewhere."

Angelos Chaniotis, Professor in the School of Historical Studies, specializes in Hellenistic history and uses epigraphic evidence, like inscriptions, as the source for social and religious history as well as the history of emotions, memory, and identity in the ancient world. He has addressed topics such as the role of inscriptions in the historical consciousness of ancient Greece, the importance of emotions in the cult practices of the eastern Roman Empire, and the cultural history of war in the Hellenistic period. He was recently awarded the Anneliese Maier Research Award from the Alexander von Humboldt foundation.

Graffiti such as these—children of the night, products of conflicts, and media of slander—existed in ancient cities in large numbers, mostly written with charcoal or paint on plastered walls. Large groups of graffiti have survived in Pompeii, in a subterranean construction in Smyrna, and in a large house in Ephesos.[2] They were ephemeral texts, addressed to contemporary audiences, not to the future historian.

GRAFFITI REFLECT IN A MORE DIRECT WAY THAN OTHER CATEGORIES OF INSCRIPTIONS THE THOUGHTS AND FEELINGS OF SIMPLE PEOPLE, ABOUT WHICH OTHER SOURCES OFTEN ARE SILENT.

Only those who knew names and contexts could understand them and appreciate the jokes. Most of such graffiti have been lost together with the wall plaster on which they were written. Together with them is lost also ephemeral poetry, such as the one described by the Roman poet Martial (12.61.7–10):

> If you are eager to be read of, then look for some drunk poet of the dark archway, who writes poems with rough charcoal or crumbling chalk, which people read while they take a shit.

Graffiti are unofficial texts and images, expressions of thoughts and feelings of ordinary people. For this reason they are a valuable source for social, political, and cultural history, but only when a historian can place them in historical contexts and correlate them with other sources of information. Aphrodisias is one of the rare cases in which this is possible.

Aphrodisian graffiti: an overview

From the late first century B.C.E. to the seventh century C.E., Aphrodisias was one of the most important urban centers in Asia Minor. The city owed its name and its fame to the sanctuary of an old Anatolian goddess of fertility and war who, in the second century B.C.E. at the latest, was identified with the Greek Aphrodite. As a loyal ally of Rome, but also because Aphrodite was regarded ancestor of the Roman imperial family, Aphrodisias received political and economic privileges. Thanks to imperial support and the exploitation of marble quarries, the city of Aphrodite grew into a prosperous urban center and a leader in ancient sculpture. The New York University excavations, under Kenan Erim (1961–90) and Bert Smith (from 1991 onwards), have made Aphrodisias one of the most important archaeological sites in Asia Minor.

Almost all graffiti that had been incised or painted on plastered walls have now been lost, but the textual and pictorial graffiti that have been engraved and chiseled on marble have been preserved. Thousands of them have been recorded in the last decades.[3] I can find no explanation for the great number, variety, and sometimes good quality of the Aphrodisian graffiti other than the fact that a substantial part of the population was involved in the carving of stone, as sculptors and masons. I assume that graffiti were primarily made by artists and workers who visited the theater, the stadium, and the markets with their implements. Graffiti, therefore, primarily reflect the thoughts and emotions of men—possibly also of children, apprentices in these crafts.

The Aphrodisian graffiti range from obscene texts and images (Figure 1), prayers, religious symbols, and simple personal names to representations of entertainers, gladiators, and wild animals (Figure 2), drawings of faces and objects, and acclamations for popular public figures, professional guilds, and teams of charioteers. Some of the pictorial graffiti are of high quality and resemble images in contemporary metal objects and glass vases (Figure 3). But some images are very rude sketches, resembling drawings made by children—and possibly, indeed made by children.

Exactly because of their non-monumental, private, and sometimes spontaneous nature, graffiti reflect in a more direct way than other categories of inscriptions the thoughts and feelings of simple people, about which other sources often are silent. Their backgrounds are, however, difficult to reconstruct. Only graffiti which belong to large groups or whose contexts are known can meaningfully be exploited as a source of information for everyday life and society. For instance, a quite accurate outline of the city wall scratched on the south wall can be roughly dated to ca. C.E. 365–370, that is, the construction period of the wall.[4] And it provides the context for understanding another graffito engraved close to it. The text reads *ORTHON* ("Upright!"). It is the acclamation of workers or spectators when the construction of the fortification wall was completed: "May the city wall remain upright." This wish was indeed fulfilled.

The following examples demonstrate how graffiti

(Continued on page 7)

ALL IMAGES ANGELOS CHANIOTIS

Examples of Aphrodisian graffiti (from left to right)—Figure 1: Obscene texts and images. Figure 2: Representations of entertainers, gladiators, and wild animals. Figure 3: Drawings that resemble images in contemporary metal objects and glass vases.

can provide information for interpersonal, social, and religious conflicts in Late Antique Aphrodisias.

Claiming professional space, cheering a team, insulting a governor

A graffito engraved on the huge retaining wall of the theater, which marks the south end of a large open space usually called the South Agora, reads "Place of Zotikos, the trader. Good luck" (Figure 4). Zotikos may have had a second booth at the northwest end of the South Agora, where we find another graffito: "Place of Zotikos." On a column of the north colonnade of the same South Agora we read the word *SOPHISTOU* ("The place of the sophist"). It is here that in Late Antiquity a teacher of language and oratory met his pupils. Many graffiti in Aphrodisias are connected with the efforts of professionals—barbers, teachers, traders, etc.—to secure for themselves space in this area for their activity. Unfortunately, we have no information about whether they were assigned the space by civic authorities or by a professional guild, paying a fee. Nevertheless, such graffiti allow us to have a vivid impression of the various activities that took place in the public spaces.

As recent excavations in the South Agora by Andrew Wilson (University of Oxford) have shown, this public space, consisting of a large pool surrounded by porticos and a palm grove, was one of the most lively parts of the city, suitable for shopping, relaxed walks, but also agitated discussions among the followers of different statesmen, different religions, and different teams of charioteers. "The Fortune of the Red wins" is written by supporters of the red team on two slabs. Game boards engraved on the plaques of the pool and the pavement of the porticos, religious symbols on columns and pavements, images connected with shows and competitions, and acclamations provide valuable clues about activities but also about conflicts and tensions.

A graffito in a game board names a prominent figure (Figure 5): the provincial governor Dulcitius, who was involved in the restoration of the Agora Gate in the late fifth century C.E. The text is not well preserved, but it seems to be a joke on him. It probably reads "Eusebius screws Dulciti(u)s." Obscene words such as this were used as insults. Their authors wanted to humiliate and insult their opponents. By ascribing them the passive part in sexual intercourse, they indicated that they were inferior and defeated. Since Dulcitius seems to have been a sympathizer of the traditional religion and Eusebius is a common Christian name, it is possible that the unknown conflict between Dulcitius and Eusebius was religious in nature: the conflict between a Christian and a "pagan." At more or less the same time, acclamations at the west end of the same public space express the wish that the enemies of the Christian benefactor Albinus be thrown into the river ("The whole city says this: Your enemies to the river! May the great God grant this!").

Graffiti as these help us somehow fill this and other public spaces of Aphrodisias with life and voices. *PHILO EPIKRATEN* ("I love Epikrates" or rather "I am a friend of Epikrates") is written on a column of the Sebasteion, a building complex dedicated to the cult of the emperor. Is this an expression of genuine feelings or of flattery? Such graffiti often remain enigmatic, because their backgrounds are elusive. But sometimes we can be certain that they are expressions not of affection between equals but devotion in hierarchical relations. "I love Apollonios, the master" is written on a column, a declaration of a servant who wants his master to know about his devotion. Such declarations were public performances, texts meant to be read, possibly to be read aloud. They presuppose competition. The slave who declares his love to his master presupposes another slave who hates this (or a different) master. The friend of Hypsikles presupposes his enemy.

Religious conflicts

One particular form of competition and conflict was very prominent in Late Antiquity: the conflicts between religious groups. When Emperor Galerius put an end to the prosecution of the Christians and (for a short period of time) to the discrimination of the Jews in 311 C.E., an intense competition among religions emerged, which ended with the final victory of Christianity. In Aphrodisias, the resistance of the followers of the Hellenic religion lasted until the early sixth century. Supported by the imperial administrations, the Christians engraved religious symbols (crosses, fish), prayers, and acclamations on walls. One such graffito is worth a closer look (Figure 6). At first sight it looks like an abecedary, a list of letters of the Greek alphabet: alpha, beta, gamma, delta, epsilon. But zeta and eta do not appear in their proper places, before theta; instead, they are scratched above and below the other letters. The puzzle is solved when we observe that the letters are arranged in the form of a cross. In this arrangement, zeta and eta, together with the cursive beta (which resembles an omega), produce the word ZOE, "Life." This is not part of the alphabet, but a Christian declaration of faith and hope in eternal life. We cannot determine whether this symbol was engraved before or after the end of Christian prosecutions, but it was certainly engraved in a period of religious competition.

Also, the opponents of Christianity have left their traces on the walls of the buildings. Numerous Jewish graffiti, usually *menoroth*, lamps with seven arms, can be seen in shops owned by Jews in the Sebasteion and the South Agora. As for the pagans, they responded to the Christian cross by engraving their own symbol, the double axe (*labrys*), the symbol of the Carian Zeus. Such graffiti reveal the importance of religious identities for the inhabitants of Aphrodisias and the bitter competition among Jews, Christians, and pagans.

The graffiti of Aphrodisias show that the study of the social history of an ancient city needs to take into consideration all types of evidence: texts and images, works of literature and documents, the masterpiece of an inspired and inspiring mind, and the humble expressions of the thoughts and feelings of ordinary people. This approach can be rewarding. It enables us to have a better picture of the dreams and nightmares, the hopes and the fears of human beings in times past. The graffiti, which are related with religious conflicts, address a very familiar issue: how religion divides and splits communities. Such graffiti are still relevant. ■

Recommended Reading: "Gladiator Fights Revealed in Ancient Graffiti," Owen Jarus, *Live Science* (June 15, 2015): http://bit.ly/1G7tZHQ

1 Strabo 14.514.

2 Pompeii: e.g., R. E. Wallace, *An Introduction to Wall Inscriptions from Pompeii and Herculaneum*, Wauconda, Il. 2005; K. Milnor, *Graffiti and the Literary Landscape in Roman Pompeii*, Oxford 2014. Smyrna: R. S. Bagnall, *Everyday Writing in the Graeco-Roman East*, Berkeley/Los Angeles 2011. Ephesos: H. Taeuber, "Graffiti," in F. Krinzinger et alii (eds.), *Hanghaus 2 in Ephesos: Die Wohneinheiten 1 und 2. Baubefund, Ausstattung, Funde*, Vienna 2010, 122–25 and 472–78.

3 For earlier collections of graffiti in Aphrodisias, see C. Roueché, *Aphrodisias in Late Antiquity*, London 1989; *Performers and Partisans at Aphrodisias*, London 1993; and "Late Roman and Byzantine Game Boards at Aphrodisias," in I. Finkel (ed.), *Ancient Board Games in Perspective*, London 2007, 100–05; M. Langner, *Antike Graffitizeichnungen: Motive, Gestaltung, und Bedeutung*, Wiesbaden 2001. Many graffiti could be recorded from 1995 to 2014 by the author and members of the excavation team (especially Ioannis Mylonopoulos, Peter De Staebler, and Andrew Wilson). For an overview, see A. Chaniotis, "Graffiti in Aphrodisias: Images—Texts—Contexts," in J. A. Baird and C. Taylor (eds.), *Ancient Graffiti in Context*, London 2011, 191–207.

4 P. De Staebler, "The City Wall and the Making of a Late-Antique Provincial Capital," in C. Ratté and R. R. R. Smith (eds.), *Aphrodisias Papers 4: New Research on the City and its Monuments* (*Journal of Roman Archaeology, Supplement* 70), Portsmouth 2008, 284–318.



Figure 4: A graffito engraved on the huge retaining wall of the theater, which marks the south end of a large open space usually called the South Agora, reads "Place of Zotikos, the trader. Good luck." Figure 5: A graffito in a game board names and insults a prominent figure, the provincial governor Dulcitius. Figure 6: A word puzzle engraved during a time of religious competition.

Beyond the Higgs: From the LHC to China

Nima Arkani-Hamed leads efforts to build Higgs factory and super collider

Three years ago, just before it was scheduled to shut down in preparation for its second phase, the Large Hadron Collider (LHC) discovered the Higgs boson. Its discovery was expected, having been predicted nearly sixty years earlier by Peter Higgs, but the LHC-produced particle is bizarre and puzzling.

"There are all sorts of issues, theoretical issues surrounding the Higgs, which are very mysterious," says Nima Arkani-Hamed, Professor in the School of Natural Sciences. "The Higgs is the first truly new kind of elementary particle that we have discovered in four decades, and it is really a strange object." Point-like with no properties aside from a mass of 125 gigaelectronvolts (GeV), the Higgs particle does not have any charge or spin. It is also the only known particle with the ability to interact with itself.

Faced with such a compelling cliffhanger, Arkani-Hamed headed to China. "I thought the most effective thing I could do to push this part of physics forward is to try to make sure that the next machine happens," says Arkani-Hamed. "I thought I could usefully engage a large pool of talent among young people who are experts in how all of these colliders work, who also were looking for something to do in the gap period between when the LHC shut off and turned on again."

Arkani-Hamed joined forces with Yifang Wang, Director of the Institute of High Energy Physics in Beijing, and became the first Director of Beijing's new Center for Future High Energy Physics. For the last two years, Arkani-Hamed has worked with Wang and others to articulate the case for building a Higgs factory known as the Circular Electron Positron Collider (CEPC), followed by a Super Proton Proton Collider (SPPC), a 50- to 100-kilometer-long circular collider outside of Beijing, which would provide a significant upgrade from the LHC's 17-mile-long design.

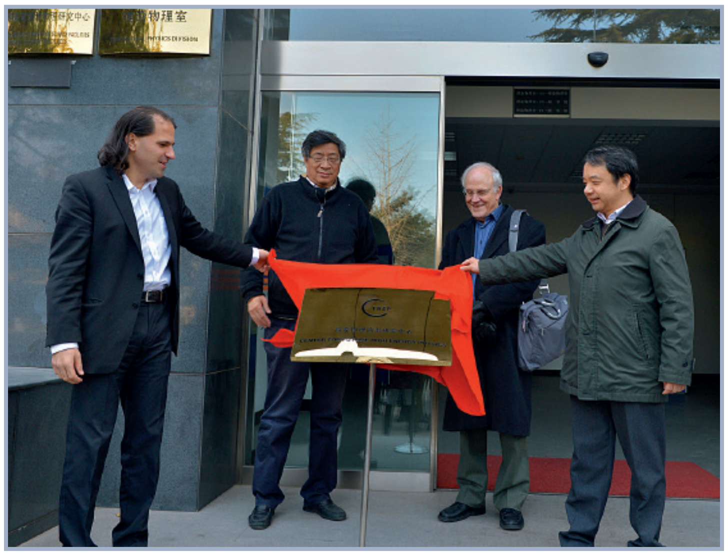
Last year, Arkani-Hamed was in Beijing for roughly a week every month, working to finalize two reports (more than 700 pages altogether; see box for a link to the reports) that were submitted to the Chinese government this spring––making the physics argument for the colliders and describing how they would be built—with the aim of securing five-year funding for the project. If everything moves forward as proposed, the government's approval of research-and-development funding for the next five years would be followed by the digging of a tunnel by 2020. Collision data from the Higgs factory would be available by the end of the decade.

The LHC turned back on in June at a record-breaking 13 teraelectronvolts (TeV)—twice the energy level of the previous run, which allows for the possible discovery of particles that may have been at the edge of detectability (such as supersymmetric and/or dark matter particles). But this next run of the LHC won't lead to a greater understanding of the Higgs, whose mass makes it difficult for the collider to obtain a very precise picture, even at its new energy.

The proposed CEPC would provide a microscope for studying the Higgs, particularly whether the Higgs might, after all, be a composite with some structure. "The really central question that we are interested in is: how point-like does it seem? If it had substructure, everything would be okay. If it had some discernible size, we would not freak out as theorists. We would understand. We would be happy," says Arkani-Hamed. "But more and more, it looks like it doesn't have substructure. You probe to shorter and shorter distances—it still seems to be completely featureless and the stranger and stranger things become. The LHC itself is only going to give us a pretty fuzzy picture of it."

Most theoretical physicists, including Arkani-Hamed, believe there has to be something beyond the Higgs—either supersymmetric particles or other new particles that the LHC may discover as soon as the end of this year. "If we see something beyond the Higgs: spectacular," says Arkani Hamed. "If we don't see something beyond the Higgs: extremely disquieting, extremely weird. It throws down a big challenge to a theorist to try to figure out what to make of it."

CENTER FOR FUTURE HIGH ENERGY PHYSICS



Clockwise from left: Nima Arkani-Hamed, Chen Hesheng, Nobel Laureate David Gross, and Yifang Wang at the inauguration of the Center for Future High Energy Physics in Beijing on December 17, 2013

China is not the only entity interested in hosting the next-generation collider. The European Organization for Nuclear Research (CERN), which operates the LHC, is exploring the idea, as is Japan.

The Higgs boson explains how most fundamental particles acquire mass as they interact with a Higgs field that exists everywhere in the universe. It was the final element of the Standard Model that needed to be confirmed experimentally, and its discovery promises to provide further understanding of the origin of mass and help clarify some long-standing mysteries.

"Thinking about where the Higgs might come from, it starts getting very, very confusing," says Arkani-Hamed. "Precisely how the field of particle physics will develop is going to depend an enormous amount on what we actually learn. Whatever we learn is going to throw the field down one road or another."

The LHC is a proton-proton collider that produces the Higgs particle along with dozens of other particles. The proposed CEPC would collide electrons and positrons tuned to energies that would produce millions of Higgs particles in an extremely clean environment. This would lead to a more precise understanding of how Higgs particles are produced and how they decay. The CEPC would show how other particles interact with the Higgs and how point-like the particle looks to external probes.

The first phase would focus on these microscopic studies of the Higgs. The second phase would commence in about fifteen years and involve the building of the SPPC at energies of 100 TeV, a little more than seven times higher than the current energy level of the LHC. In addition to pushing the high-energy frontier, the SPPC would test how the Higgs interacts with itself and whether it interacts with itself in the way it would if it were truly point-like. (One reason for this fifteen-year timescale is that the stronger magnets, produced by Fermilab in the United States, which are needed to get to these incredibly high energies, will take that long to make.)

The physics community, particularly in the United States, still bruisingly recalls when Congress officially killed the U.S. effort to build a supercollider in 1993, transferring U.S. dominance in high-energy physics to Europe when it successfully built CERN's LHC. When Arkani-Hamed first traveled to China to talk to Wang and others who are leading the effort to build the next-generation collider there, it quickly became obvious to him that they were very serious.

"China brings to this entire discussion a certain level of newness. They are going to need help, but they have financial muscle and they have ambition," says Arkani-Hamed. "It would be fantastic for physics to get them involved in this endeavor––a big-scale scientific project that China can do with guaranteed success: they build it and people come, no ifs, ands, or buts."

The building of the proposed colliders would be a huge leap for China—to support it, the size of the Chinese physics community would need to increase dramatically. As Director of the Center for Future High Energy Physics, Arkani-Hamed recruited forty to fifty of his closest friends and colleagues to come to Beijing, study the physics potential of these machines, give lectures, interact with the Chinese physics community, and "start trying to drum up excitement and enthusiasm for the whole project, not just in China, but around the world."

If the project moves forward, Arkani-Hamed envisions being involved at an educational level, helping to develop an international program where fundamental physics is introduced to undergraduate sophomores and perhaps rotates between China, Fermilab, and CERN.

"It is extremely interesting to think about getting sophomores up to the speed of a second-year graduate student. I think it is possible," says Arkani-Hamed. "The scale is going to have to be huge. We are talking about hundreds of people involved in programs like this."

Driving Arkani-Hamed is the sense that physics is on the threshold of a new, eye-opening era. In the film *Particle Fever*, Arkani-Hamed and physicist Savas Dimopoulos are positioned as supporters of two distinct theories—multiverse (Arkani-Hamed) versus supersymmetry (Dimopoulos)—but a decade ago the two wrote a paper together that suggested a theory in between that fits very well with a Higgs that has the mass of 125 GeV discovered by the LHC.

"Like everyone in the field, I care about this physics a lot," says Arkani-Hamed. "There was a period where it made a lot of sense for theorists to hypothesize and theorize a lot, and I did more than my share of that and people are continuing to do it. I personally transitioned away from that momentarily, because we are just about to find out whether the answer to some of these questions is roughly along the lines of what we expected. I am waiting on pins and needles."—*Kelly Devine Thomas, Editorial Director, kdthomas@ias.edu*

Recommended Reading: Copies of the reports—making the physics argument for the colliders and describing how they would be built—submitted to the Chinese government are available at http://cepc.ihep.ac.cn/preCDR/volume.html.

Studying Physics in America

A short examination of Chinese physicists in the early twentieth century

BY DANIAN HU[1]

Addressing an international audience in 2004, Professor Dong Guangbi, an erudite historian of science, summarized Chinese physics development over the previous century, and he argued that the country from which Chinese physicists and physics benefited most was the United States of America.[2] Dong's argument was supported by the background of the seven "most creative Chinese physicists."

TABLE 1. MOST CREATIVE CHINESE PHYSICISTS IN THE 20TH CENTURY[3]

NAME	DATE AND COUNTRY FOR DOCTORATE
Chi-Sun Yeh 叶企孙 (1893–1977)	1923, U.S.A.
Pei-Yuan Chou 周培源 (1902–93)	1928, U.S.A.
Kan-Chang Wang 王淦昌 (1907–98)	1933, Germany
Ta-You Wu 吴大猷 (1907–2000)	1933, U.S.A.
Chen-Ning Yang 杨振宁 (1922–)	1948, U.S.A.
Tsung-Dao Lee 李政道 (1926–)	1950, U.S.A.
Guangzhao Zhou 周光召 (1929–)	1952, China

Five out of these seven received doctorates in America and four of the five—Chou, Wu, Yang, and Lee—were former Members of the Institute for Advanced Study, indicating the dominating American influence and the significant role of IAS in Chinese development. This essay supports Dong's thesis with additional evidence revealed in my preliminary survey of Chinese physicists schooled in America during the first half of the twentieth century.

Yuanli Hsia

FIVE OUT OF THESE SEVEN RECEIVED DOCTORATES IN AMERICA AND FOUR OF THE FIVE—CHOU, WU, YANG, AND LEE—WERE FORMER MEMBERS OF THE INSTITUTE FOR ADVANCED STUDY, INDICATING THE DOMINATING AMERICAN INFLUENCE AND THE SIGNIFICANT ROLE OF IAS IN CHINESE DEVELOPMENT.

The first Chinese physicist to graduate from an American college was most likely Yuanli Hsia (夏元瑮, 1883–1944), one of a few in the first generation of Chinese physicists. Sponsored by the Guangdong Provincial Government, Hsia came to study at Yale University. Upon his graduation in 1907, Hsia went on to the University of Berlin where he studied with Max Planck and Heinrich Rubens before his return to China in 1912. He then served six years at Peking University as dean of the School of Sciences. Remarkably, Hsia did not accept Einstein's theory of relativity before 1919 when he returned to Berlin and met Einstein through Planck. Hsia's early resistance to relativity seemed to be partially influenced by his Yale professor Henry Bumstead. After studying with Einstein during 1919–1921, however, Hsia became an active and enthusiastic relativist who delivered numerous speeches and published many articles in China, expounding and advocating Einstein's theories. He produced in 1921 the first Chinese translation of Einstein's only popular book, *Relativity: The Special and General Theories*.

Hsia was a major contributor to the "relativity boom" in early 1920s China.[4] Hsia's schoolmate at Yale, Tatsung Chang (1883–1978) graduated in 1909, majoring in electrical engineering, later joined Hsia at Peking University in 1913, and chaired the physics department in 1920. Both Hsia and Chang received only Ph.B. degrees before leaving America.[5]

The first Chinese physics doctorate in America was John Yiubong Lee (李耀, 1884–ca. 1940), who graduated from the University of Chicago in 1915 under the direction of Robert Millikan. However, Lee gave up his academic career in 1917, only two years after his return to China. Another Chinese student of Millikan's in Chicago was Kia-Lok Yen (颜任光, 1888–1968), who earned his Ph.D. with a philosophy instead of a physics thesis in 1918. Yen joined the physics faculty of Peking University in 1920 and later succeeded Chang as the department chair. Yen was a pioneer and advocate in China for teaching physics through experiments. After spending a year (1924–25) at the Cavendish Laboratory, Yen left Peking University to establish the first Chinese plant manufacturing scientific instruments in Shanghai because he was firmly convinced that the lack of experimental instruments was a vital obstacle hindering the progress of Chinese physics studies.[6] During the 1910s, there were only two Chinese students who received American doctorates in physics.[7] The second was Kang-Fuh Hu, one of the first students funded by the Boxer Scholarship to study in America.[8]

In 1908, the American government agreed to return the excess Boxer indemnity (the first remission: $11 million) to China but demanded its application to financing Chinese students' education in America—hence the creation of the Boxer Scholarship.[9] The first batch of Boxer Scholars left China for America in 1909.[10] This new fund had far-reaching impact on the development of Chinese science and technology in the following decades.[11] In the 1920s, the number of Chinese physics doctorates in America increased to eighteen, of which at least six were Boxer Scholars.[12]

Among these eighteen doctorates were Yu-Tai Yao, Chi-Sun Yeh, and Yui-Hsun Woo. A graduate of Tsinghua, Yeh was also a Boxer Scholar. These three, together with Hu, were later identified as China's four pioneer researchers and devoted mentors in physics (see Table 2 for detailed data). To commemorate their contributions, the Chinese Physical Society established in 1988 four premier awards in their names.[13]

(Continued on page 10)

1 I gratefully acknowledge the support of the Agnes Gund and Daniel Shapiro Fund at IAS, The Simon H. Rifkind Center for the Humanities and the Division of Humanities and Arts at The City College of New York, and the Max Planck Institute for the History of Science, Berlin, Germany, which made relevant research possible. My thanks also go to Professor Freeman Dyson for sharing with me his personal association with Chinese physicists, and to Marcia Tucker, Erica Mosner, Momota Ganguli, Karen Downing, and Terrie Bramley at the IAS for their generous support. Last but not least, I thank Professor David Bello for his kind help in many ways.

2 Guangbi Dong, "20世纪的中国物理学 [Physics in Twentieth-Century China]," in 第十届中国科学史国际会议 [*The Tenth International Conference of the History of Science in China*] (Harbin, China: 2004). Dong is a research professor at the Chinese Academy of Sciences.

3 Zhou completed his graduate studies at Peking University in 1954 when a doctorate degree was not available (until 1981), but one could argue that Zhou's accomplishment made him a doctorate equivalent. 中国现代物理学史 [*A History of Physics in Modern China*], Zhongguo Jin Xian Dai Ke Xue Ji Shu Shi Yan Jiu Cong Shu (Jinan Shi: Shandong jiao yu chu ban she, 2009), 58.

4 In present pinyin, "Yuanli Hsia" is also spelled as "Xia Yuanli." See detailed discussion on Hsia (Xia) in Danian Hu, *China and Albert Einstein: The Reception of the Physicist and His Theory in China, 1917–1979* (Cambridge, Massachusetts: Harvard University Press, 2005), 89–98; "Two Chinese Pioneers of Relativity [在中国传播相对论的两位先驱]," 自然科学史研究 *Studies in the History of Natural Sciences* 24 Suppl. (2005).

5 For Chang's career before 1917, see Frank G. Burke, Jr., et al., ed., *Class History 1909, Sheffield Scientific School, Yale University*, vol. I (New Haven, Connecticut: 1909); Guok-Tsai Chao, ed., *Who's Who of American Returned Students* (Peking, China: Tsing Hua College, 1917). Ph.B. degree: John L. Bagg, ed., *Class History 1909, Sheffield Scientific School, Yale University*, vol. II (Holyoke, Massachusetts: 1915), 28. Chang left Peking University for "the College of Salt Administration in 1920": see John B. Wallace, Jr., ed., *Quarter Century Record, 1909, Sheffield Scientific School, Yale University*, vol. IV (New Haven, Connecticut: The Class Secretaries Bureau, 1935), 48.

6 Qu Jingcheng 屈儆诚, "Chinese Physicists Educated in Germany and America: Their Scientific Contributions and Their Impact on China's Higher Education (1900–1949)" (The Ohio State University, 1998), 141–48. Kia-Lok Yen, "The Traditional and the Scientific Trends in the Logic of Leibnitz" (Ph.D. dissertation, The University of Chicago, 1918).

7 Ibid., 311–15. Based on his dissertation, Yen was not a doctorate in physics.

8 中国科学技术专家传略 理学篇 物理学卷 I [*Short Biographies of Chinese Specialists in Science and Technology. Collections of Scientists: Physicists I*], ed. Zhongguo ke xue ji shu xie hui (Shijiazhuang Shi: Hebei jiao yu chu ban she, 1996), 67–75; Boxer scholar, 68.

9 For detailed analysis of the American remission, see Michael H. Hunt, "The American Remission of the Boxer Indemnity: A Reappraisal," *The Journal of Asian Studies* 31, no. 3 (May 1972).

10 Chen Xuexun 陈学恂 and Tian Zhengping 田正平, eds., *Liu Xue Jiao Yu* 留学教育 [*Education through Studying Abroad*], Zhong Guo Jin Dai Jiao Yu Shi Zi Liao Huibian 中国近代教育史资料汇编 [Collected Historical Materials of Modern Chinese Education] (Shanghai, China: Shanghai Education Press, 1991), 172.

11 The remitted Boxer indemnity also helped to support various educational and cultural projects in Republican China. Many Boxer Scholars later became leading Chinese physicists in the twentieth century, which is, I believe, why Chen Ning Yang in his speech at the 1957 Nobel Banquet regarded the Boxer Uprising as a "momentous event" that was "of great historical importance" for Chinese physics development. ("Chen Ning Yang—Banquet Speech," www.nobelprize.org/nobel_prizes/physics/laureates/1957/yang-speech.html, accessed April 17, 2015.) For the specific number of Chinese students selected as Boxer Scholars in 1909, 1910, and 1911, see Qu Jingcheng 屈儆诚, "Chinese Physicists Educated in Germany and America: Their Scientific Contributions and Their Impact on China's Higher Education (1900–1949)," 131–32.

12 Ibid., Appendix B.

13 Chinese Physical Society, "中国物理学会胡刚复、饶毓泰、叶企孙、吴有训、王淦昌物理奖章程 [CPS Bylaws for Kang-Fuh Hu, Yu-Tai Yao, Chi-Sun Yeh, and Y. H. Woo Prizes]," www.cps-net.org.cn/twotile/jlxx/wjzc.htm; "中国物理学会胡刚复、饶毓泰、叶企孙、吴有训、王淦昌物理奖历届获奖人员名单 [All Previous CPS Awardees of the Kang-Fuh Hu, Yu-Tai Yao, Chi-Sun Yeh, and Y. H. Woo Prizes]," www.cps-net.org.cn/twotile/jlxx/wjtj.htm, accessed May 26, 2015. A fifth prize was added in 2000 to commemorate Kan-Chang Wang. www.dfzqw.net/UploadFile/2013-8/20138121841246634.jpg. http://images.blogchina.com/artpic_upload/2013/04/f733e53c108253e318e70c02647d3a1b.jpg. http://s9.sinaimg.cn/mw690/001Ytnrdzy6PbawHjXq58&690.

14 中国科学技术专家传略 理学篇 物理学卷 I [*Short Biographies of Chinese Specialists in Science and Technology. Collections of Scientists: Physicists I*].

Table 2. Data of The Four Great Chinese Physicists[14]

NAME AND DATES	 K. F. HU 1892–1966	 Y. T. YAO 1891–1968	 C. S. YEH 1893–1977	 Y. H. WOO 1897–1977
DATES OF AMERICAN EDUCATION	1909–18	1913–22	1918–23	1922–26
INSTITUTIONS ATTENDED	Harvard (B.S., M.S., Ph.D.)	Chicago (B.S.), Harvard, Yale, Princeton (Ph.D.)	Chicago (B.S.), Harvard (Ph.D.)	Chicago (Ph.D.)
DOCTORAL ADVISER	W. Duane	K. T. Compton	P. W. Bridgman	A. H. Compton
POSITIONS HELD IN CHINA	Taught at six universities; Dean of Sci. at Zhejiang Univ.; Pres. of Datong Univ.	Dept. Chair, Dean of Sci. at Nankai Univ. and Peking Univ.	Dept. Chair, Dean of Sci. at Tsinghua Univ.; S.G. Academia Sinica	Dept. Chair, Dean of Sci. at Tsinghua Univ.; Pres. of Central Univ.; D. Pres. of the Chinese Acad. of Sci.
DISTINGUISHED STUDENTS	Y. H. Woo, Tsi-Zé Ny, C. Y. Chao, etc.	Ta-You Wu, S. T. Ma, Y. H. Kuo, etc.	K. C. Wang, T. S. Chang, N. Hu, C. C. Lin, etc.	San-Tsiang Tsin, C. N. Yang, T. D. Lee, etc.

It is remarkable that all of these four physicists were experimentalists. In fact, there were no Chinese theoretical physicists until 1928 when two Chinese theorists, Shou-Chin Wang (1905–84) and Pei-Yuan Chou (1902–93), earned their doctorates at Columbia and Caltech respectively. Both Wang and Chou graduated from Tsinghua College, an institution founded with the Boxer indemnity returned by America, and then went on to America in 1924 funded by the Boxer Scholarship. Wang was a rare talent in his generation who went directly to Harvard graduate school from Tsinghua, whereas his classmates began as college sophomores or juniors.[15]

After earning his M.S. at Cornell in 1925 and A.M. at Harvard in 1926, Wang transferred to Columbia University where he joined a small group of friends and fellow graduate students organized by I. I. Rabi to study the new quantum mechanics, which nobody taught at the university. In December 1927, Wang submitted his dissertation, "The Problem of the Normal Hydrogen Molecule in the New Quantum Mechanics," which no faculty member at Columbia was able to direct.[16] Nevertheless, Wang received his Ph.D. in June 1928 and became one of the first five doctorates in America whose theoretical thesis dealt specifically with quantum mechanics. It is remarkable to note that Wang was the only one in the group who did not have a thesis supervisor![17] As a foreigner, Wang even won a 1928–1929 National Research Fellowship, allowing him to work with J. H. Van Vleck at the University of Wisconsin before returning to China.[18] Wang taught at Zhejiang and Peking Universities successively between 1929 and 1933.


Pei-Yuan Chou

But then, in view of the increasing Japanese threat to China since 1931, Wang decided to leave academia and accepted the government's appointment to lead a national project of machine building. He later became the father of China's heavy industry.[19]

Chou, Wang's classmate and good friend at Tsinghua, first attended the University of Chicago where he managed to earn both bachelor's and master's degrees within two years before leaving for Pasadena in early 1927. At Caltech, Chou worked with H. Bateman, B. Podolsky, and E. T. Bell and completed his dissertation on Einstein's theory of gravitation under Bell's supervision, receiving his doctorate only one day after Wang did.[20] After visiting physicists at Harvard, Princeton, and Cornell in the summer of 1928, Chou traveled to Europe in the fall, visiting Niels Bohr in Copenhagen, doing postdoc work with Werner Heisenberg (together with I. I. Rabi) in Leipzig and with Wolfgang Pauli in Zurich until his departure for Tsinghua University in late 1929. For the next twenty-three years, Chou served Tsinghua as its only leading theorist, but he began to transform his research program in late 1937 from general relativity and cosmology to turbulence in the face of the Japanese invasion, hoping to serve his motherland with intellectual products applicable to national defense.[21] Wang and Chou, specializing in quantum mechanics and relativity respectively, would have been a pair of ideal leaders for Chinese theoretical physics, but, alas, both were forced to give up their promising research agenda as a consequence of the Japanese invasion.[22]

Nevertheless, Chou, a devoted mentor, nurtured many talented theorists over his tenure at Tsinghua, with J. S. Wang, T. S. Chang, H. W. Peng, C. C. Lin, and N. Hu standing out (see Table 3).[23]

Table 3. Chou's Five Tsinghua Graduates

NAME	BACHELOR'S DEGREE	DOCTORATE(S), INST. & DATES	SUPERVISOR(S)	IAS MEMBERSHIP
Jwu-Shi Wang	1933	Ph.D. 1938, Cambridge	R. H. Fowler, J. K. Roberts	
Tsung-Sui Chang	1934	Ph.D. 1938, Cambridge	R. H. Fowler	1947–48
Hwan-Wu Peng	1935	Ph.D. 1940, D.Sc. 1945, Edinburgh	M. Born	
Chia-Chiao Lin	1937	Ph.D. 1944, Caltech	T. von Kármán	1959–60 & 1965–66
Ning Hu	1938	Ph.D. 1943, Caltech	P. Epstein	1943–45

After returning to China from Cambridge, J. S. Wang supervised C. N. Yang's master's thesis in Kunming and kindled Yang's life-long interest in statistical physics. Paul Dirac invited Chang to teach quantum field theory at Cambridge in 1946–47 before bringing him to the IAS; decades later, Yang praised Chang as "a most brilliant physicist."[24] Peng collaborated closely with Max Born and succeeded Walter Heitler as an assistant professor at the Dublin Institute for Advanced Study

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15 Hu Shenghua 胡升华, "王守竞的量子力学研究成果及其学术背景 [S. C. Wang's Accomplishments in Quantum Mechanics Studies and Their Academic Context]," 中国科技史料 [*China Historical Materials of Science and Technology*] 21, no. 3 (2000): 235.

16 S. C. Wang, "The Problem of the Normal Hydrogen Molecule in the New Quantum Mechanics," *Physical Review* 31, no. 4 (1928): VITA at the end and 586; John S. Rigden, *Rabi, Scientist, and Citizen*, Alfred P. Sloan Foundation Series (New York: Basic Books, Inc., 1987), 42, 39.

17 At the end of his thesis, Wang thanked A. P. Wills's "encouragement and kindness in going over the manuscript," indicating that Wills might have played the key role in persuading the physics department to accept Wang's thesis. On the first seven American doctoral theses on quantum mechanics, see Katherine Russell Sopka, *Quantum Physics in America, 1920–1935*, *Three Centuries of Science in America* (New York: Arno Press, 1980), 3.60 and 3.102. According to Web of Science, accessed June 2, 2015, Wang's thesis has been cited 320 times, which is impressive.

18 Ibid., 3.62. Wang was one of the only two physicists to receive the 1928–29 Fellowship for study in quantum mechanics at American institutions. Photo of Chou: http://img1.yododo.com.cn/files/photo/2014-12-15/014A4C766E8A04CDFF8080814A4BE63F.jpg.

19 Dong, 中国现代物理学史 [*A History of Physics in Modern China*], 22.

20 Hu, *China and Albert Einstein: The Reception of the Physicist and His Theory in China, 1917–1979*, 117–18. The title of Chou's dissertation: "The Gravitational Field of a Body with Rotational Symmetry in Einstein's Theory of Gravitation." The dates for Wang (June 7) and Chou (June 8) receiving their Ph.D.s: the author's interview with Chou's daughter, Dr. Ruling Chou, in May 2005.

21 Ibid., 118–19, 21. Chou's specialty in turbulence study served the U.S. Navy in the mid-1940s.

22 After an interruption of forty-one years, Chou resumed his study in general relativity and cosmology and published fifteen more papers when he was in his 80s. (Ibid., 121.)

23 Dong, 中国现代物理学史 [*A History of Physics in Modern China*], 63, 54, 282, 44. For Lin's data, see http://en.wikipedia.org/wiki/Chia-Chiao_Lin, accessed May 29, 2015. IAS Members' data can be found at www.ias.edu/people/cos/. Evidence has shown that Chou purposely assigned his protégés to study with certain physics masters at various institutions in the West, hoping they would later return and systematically advance the Chinese study in theoretical physics. See Xiaodong Yin and Danian Hu, "王竹溪留学剑桥 [Studying in Cambridge: Jwu-Shi Wang's Story]," 自然科学史研究 [*Studies in the History of Natural Sciences*] 33, no. 4 (2014): 460.

24 Chen Ning Yang, *Selected Papers II, with Commentaries* (Hackensack, New Jersey: World Scientific Publishing Co., 2013), 142. (In Yang's article, T. S. Chang's name is spelled "Zhang Zhong-Sui.")

25 Max Born, My *Life: Recollections of a Nobel Laureate* (London: 1978), 289. Peng's appointment at the Dublin Institute for Advanced Study, "Annual Report of the Work of the Institute and Its Consitituent Schools Presented by the Council for the Financial Year 1945–46," (Dublin: DIAS), 9. www.dias.ie/images/stories/admin/Annualreports/AR%2045-46.pdf.

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TABLE 4. FIRST SIX CHINESE PHYSICISTS AT IAS

NAME	IAS MEMBERSHIP	ACADEMIC BACKGROUND	DISSERTATION ADVISER
P. Y. Chou	1936–37	Tsinghua College; U. Chicago (B.S., M.S.); Caltech (Ph.D.)	Eric T. Bell
N. Hu	1943–45, 1945f	Tsinghua U. (B.S.); Caltech (Ph.D.)	Paul S. Epstein
C. S. Wang Chang	1945–46; 1948–49	Yenching U. (B.S., M.S.); U. Michigan (Ph.D.)	George E. Uhlenbeck
T. S. Chang	1947–48	Tsinghua U. (B.S.); Cambridge (Ph.D.)	Ralph H. Fowler
S. T. Ma	1945–47	Peking U. (B.S., M.S.); Cambridge (Ph.D.)	Walter H. Heitler
C. N. Yang	1949–54	Tsinghua U. (B.S., M.S.); U. Chicago (Ph.D.)	Edward Teller

in 1945, likely becoming "the first Chinese to get a European professorship."[25] Lin went on to become a distinguished applied mathematician and an Institute Professor of Massachusetts Institute of Technology, who was 1972–74 President of the Society for Industrial and Applied Mathematics and the first APS Fluid Dynamics Prize recipient in 1979.[26] Recommended by Paul Epstein, Hu left Caltech for the IAS in fall 1943 to work with Pauli whose encouragement led Hu to become the first to "apply EIH to the problem of gravitational radiation."[27]

Chou and his students Hu and Chang were among the first Chinese physicists to receive the honor and privilege to work at the IAS. Before 1949, there had been six Chinese physicists working at the IAS as shown in Table 4.[28]

Between 1915 and 1949, five American universities (Michigan, Chicago, Harvard, MIT, and Caltech) stood out as the leading training centers for Chinese physicists in terms of the number of doctorates they awarded to Chinese students.[29] Top among the five was the University of Michigan, which produced at least twelve Chinese doctorates in physics.[30]

Among these twelve Michigan doctorates, eight (two-thirds) were female physicists—China's first. All these Chinese women were Barbour Scholars,[31] and all except Ku graduated from American mission colleges in China. Wang and Chang were George Uhlenbeck's students and collaborators who made significant contributions to statistical physics; Chang later founded and led the first Chinese research group on controlled thermonuclear reaction.[32] Both Ta-you Wu and Chao were funded by the China Foundation, a joint Chinese-American committee managing the second American remission of the Boxer Indemnity.[33] Chu was Wu's student in wartime China and later became one of the chief organizers of China's nuclear weapons program and industry.[34] This Michigan group also had connections to IAS before 1950: as shown in Table 4, C. S. Wang Chang visited the IAS twice, whereas Ma and Yang were actually Wu's protégés in China.[35]

C. S. Wang Chang at IAS

TABLE 5. CHINESE PHYSICS DOCTORATES AT MICHIGAN BEFORE 1949

NAME	SEX	EDUCATION BEFORE MICHIGAN	DATE OF PH.D.	PH.D. ADVISER(S)	FUNDING SOURCE
Zing-whai Ku 顾静徽	F	A.B. 1926 Cornell U.; M.S. 1928 Yale U.	1931	D. M. Dennison	Barbour Scholarship
Lai-wing Fung 冯丽荣	F	B.A. 1922 Canton Christian College (Lingnan)	1932	E. F. Barker	Barbour Scholarship
Ta-you Wu 吴大猷	M	B.S. 1929 Nankai U.	1933	S. A. Goudsmit	China Foundation
I-djen Ho 何怡贞	F	B.A. 1930 Ginling College	1937	R. A. Sawyer	Barbour Scholarship
Hsi-yin Sheng 盛希音	F	B.S. 1932 Yenching U.	1939	D. M. Dennison & E. F. Barker	Barbour Scholarship
Violet Lang Wu 吴芝芝	F	B.A. 1926 Hwa Nan College	1939	E. F. Barker	Barbour Scholarship
Utah Tsao 曹友德	M	National Chiao Tung U.	1939	E. M. Baker	
Kuang-Tseng Chao 赵广增	M	B.S. 1930 Peking U.	1939	O. S. Duffendack	China Foundation
Ming-chen Wang 王明贞	F	Ginling College 1926–28; B.S. 1930 & M.S. 1932 Yenching U.	1942	G. E. Uhlenbeck	Barbour Scholarship
Chao-lan Kao 高兆兰	F	B.A. 1934 & M.S. 1936 Lingnan U.	1944	H. M. Randall	Barbour Scholarship
Cheng-shu Wang Chang 王承书	F	B.S. 1934 & M.S. 1936 Yenching U.	1944	G. E. Uhlenbeck	Barbour Scholarship
Kuang-ya Chu 朱光亚	M	B.S. 1945 Southwest Associate U.	1949	M. L. Wiedenbeck	Rackham Pre-doctoral Fellowship

This brief survey reveals the prevalent and profound American influence on Chinese physicists. As many of these American educated scientists went on to become eminent scientific leaders in twentieth-century China, the benefit of study-in-America programs on Chinese science is apparent. Two driving forces behind these programs were the Boxer Scholarship and American mission colleges in China. Whereas the former has been well studied, the latter remains largely overlooked and mysterious, requiring historical clarification. ■

Danian Hu, Agnes Gund and Daniel Shapiro Member (2014–15) in the School of Historical Studies, spent time at the Institute researching the evolution of the Chinese physics community during the twentieth century, and the interplay between science and radical sociopolitical change in China. Hu is Associate Professor at The City College of New York and author of China and Albert Einstein *(Harvard University Press, 2005).*

26 http://en.wikipedia.org/wiki/Chia-Chiao_Lin, accessed May 29, 2015.

27 For detailed discussion of Hu's effort, see Daniel Kennefick, *Traveling at the Speed of Thought: Einstein and the Quest for Gravitational Waves* (Princeton, New Jersey: Princeton University Press, 2007), 147–49.

28 Thanks to Erica Mosner at the Shelby White and Leon Levy Archives Center of the IAS for helping me collect relevant data.

29 Qu Jingcheng 屈儆诚, "Chinese Physicists Educated in Germany and America: Their Scientific Contributions and Their Impact on China's Higher Education (1900–1949)," 138; Tongli Yuan, *A Guide to Doctoral Dissertations by Chinese Students in America, 1905–1960* (Washington: 1961). I replaced Ying Fu (傅鹰) with Kuang-ya Chu (朱光亚) because Fu is generally considered a chemist and the latter's dissertation was actually completed in June 1949 despite its copyright being dated 1950 on the dissertation's cover. See Kuang-Ya Chu, "A Study on the Decay Schemes of Gold-198 and Hafnium-181 by Means of a Beta-Ray Spectrometer and Coincidence Measurements" (Ph.D. dissertation, University of Michigan, 1949).

30 I say "at least twelve" because it is apparent that both Yuan and Qu classified some physicists into other categories, which requires further study to clarify. Sources for Table 5: University of Michigan. Barbour Scholarship for Oriental Women Committee, "'Former Chinese Barbour Scholars' in 'Recipients, 1914–1983,' Box 1," in Barbour Scholarship for Oriental Women Committee (University of Michigan) Records (Bentley Historical Library, University of Michigan); Yuan, *A Guide to Doctoral Dissertations by Chinese Students in America, 1905–1960*; all original dissertations except Chao-lan Kao's (The choice of Kao's adviser is based on her coauthored paper, R. A. Oetjen, Chao-Lan Kao, and H. M. Randall, "The Infra-Red Prism Spectrograph as a Precision Instrument," *Review of Scientific Instruments* 13, no. 12 [1942]); Dong, 中国现代物理学史 [*A History of Physics in Modern China*]. I wish to thank Prof. Xiaodong Yin at Capital Normal University in Beijing for sharing with me her knowledge of Chinese Barbour Scholars and Chinese physicists at Michigan University.

31 The Barbour Scholarship for Oriental Women was created through the generosity of Levi L. Barbour. Barbour was a graduate of the University of Michigan (1863) and the Michigan Law School (1865) who went on to become a successful Detroit real estate developer. (http://quod.lib.umich.edu/b/bhlead/umich-bhl-861142?view=text, accessed May 31, 2015.) For its detailed background, see University of Michigan, "The Barbour Scholarships for Oriental Women at the University of Michigan," *University Bulletin* (Ann Arbor, Michigan: The University of Michigan, 1922).

32 Dong, 中国现代物理学史 [*A History of Physics in Modern China*], 63–64, 150–51.

33 Hunt, "The American Remission of the Boxer Indemnity: A Reappraisal," 539 n.

34 Dong, 中国现代物理学史 [*A History of Physics in Modern China*], 25–26.

35 Wu himself became an IAS Member in 1958–59. ("A Community of Scholars," Institute for Advanced Study, www.ias.edu/people/cos/users/8036, accessed June 2, 2015.)

How Topology Detects Certain Phases of Matter

A small illustration of the many wonders of mathematics

BY DANIEL S. FREED

Topology is the branch of geometry that deals with large-scale features of shapes. One cliché is that a topologist cannot distinguish a doughnut from a coffee cup: if a coffee cup were made of rubber, one could continuously deform it to a doughnut without tearing. A geometer, equipped with precision tools, can measure local quantities (distances, curvature) to distinguish the coffee cup from the doughnut. A topologist, seemingly handicapped by defective eyes, can only discern that each has one hole, so at least can distinguish both from a two-holed pretzel. But, after all, a topologist is a geometer too, and the lack of close vision can reveal a forest otherwise obscured by trees. For many problems, that global vision provides crucial insights. This has long been true internally in mathematics: topological ideas play an important role in analysis, algebra, and many other areas. In recent years, topological ideas have found applications to many problems outside of mathematics: data analysis, biology, and robotics to name just a few. My concern in this article is a particular application of topology to quantum physics.

The problem described here—the classification of phases of matter—has great current relevance. Beyond that, the story I tell is one small illustration of the many wonders of mathematics: the abstract and artistic impulses, which guide the internal development of mathematical ideas, yield theorems with unanticipated powerful applications to scientific and technological problems far removed from the original source of and inspiration for those ideas.

A simple example from geometry

Before tackling quantum physics, let's warm up with a toy example. Imagine an infinite line L on which we position n numbered balls, where n is a fixed counting number $n = 1, 2, \dots$. (The "balls" are actually idealized points with no extent, but of course in the drawings below the points have a finite size.) What we want to study are all possible configurations of these balls. In the simplest case, we have just a single ball, so we know everything by knowing its position on the line L. What if we have $n = 2$ balls? In that case, a configuration of two balls is a pair of points on the line L. What does the collection of all such pairs of points look like? Answer: a two-dimensional plane. This becomes more familiar if, following Descartes, we label each point of L with a real number x. Therefore, a pair of points on L corresponds to an ordered pair (x,y) of real numbers. The collection of all pairs is the usual x-y plane. It is clear that configurations of $n = 3$ points on L correspond to triples (x,y,z) and you can go on up from there. The space S of configurations of n balls on L is an example of a *moduli space*. A point of S has a geometric meaning: it labels a configuration of points on the line L. Significantly, S is itself a *space*, not just a discrete collection of points, so for example, we can move continuously along paths in S. Such paths correspond to motions of configurations of points, as illustrated in Figure 1. As the red point in the moduli space S moves northwest, the corresponding two balls on the line L approach each other, eventually collide, and then separate again, but now with the 1-ball to the left of the 2-ball.

Figure 1. Motion in a moduli space

What is the shape of all possible configurations? We have already answered that for $n = 1$, in which case S is a one-dimensional line, and for $n = 2$, in which case S is a two-dimensional plane. Putting on a topologist's hat, we can ask if every pair of configurations can be continuously deformed one to the other, or better ask what the set of *deformation classes* of configurations is. As we have seen, a deformation is a path in S—two configurations are in the same deformation class if and only if the corresponding points in S can be joined by a path. We use the symbol '$\pi_0(S)$' for the set of *path components* of S: two points are in the same path component if and only if they can be joined by a path. In our case there is a single deformation class: any two points in S can be joined by a (straight line) path. Try to envision this in the two-dimensional case depicted in Figure 1. Continuously contract the entire plane to a single point—simultaneously move all possible configurations to a single fixed configuration, say one where the two red balls both lie at the same point of the line L.

Daniel S. Freed (dafr@math.utexas.edu), IBM Einstein Fellow in the Schools of Mathematics and Natural Sciences (2015), works on aspects of topological field theory. His current projects are broadly related to six-dimensional superconformal field theory as well as phases in condensed matter physics. Freed is Professor in the Department of Mathematics at the University of Texas at Austin.

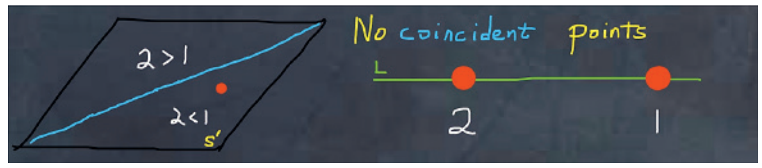


Figure 2. Moduli space of gapped configurations

So far we have no interesting topology. Now let's impose a "gap condition." Namely, let's forbid the balls (which remember are points) from coinciding. To construct the moduli space S' of gapped configurations, we begin with the moduli space S of all configurations and remove the part that corresponds to configurations in which at least two balls coincide. For $n = 2$ balls the excluded set is a line in the plane S: the diagonal blue line in Figure 2 that represents two coincident points of L. The complementary space S' has two path components. There is a simple invariant that distinguishes the two path components: the sequence of numbers of the balls on the line L read from left to right. In the case pictured in Figure 2, that sequence is (2 1); the other path component corresponds to the sequence (1 2). This sequence, called a permutation, is a deformation *invariant* of the gapped configuration, and it is a *complete* invariant in that it completely determines the deformation class of the configuration.

In summary, a metric geometer tracks the precise positions of distinct points on the line, whereas a deformation topologist only sees the permutation defined by the ordering of the points.

Moduli spaces in quantum mechanics

The moduli space of interest in our story comes not from geometry but from quantum physics. Quantum systems have parameters—one can continuously adjust temperatures, pressures, magnetic fields, etc.—and so we can envision a moduli space Q whose points represent quantum mechanical systems. As developed in the 1920s and 1930s, in large part by former IAS Professor John von Neumann, a quantum system is described by: a Hilbert space of quantum states; a Hamiltonian operator, which measures the energy; and a group G of symmetries. The Hamiltonian has a spectrum of possible energies, and again we impose a *gap condition*, this time the condition that there be a gap in the energy spectrum directly above the minimal energy. The situation is pictured schematically in Figure 3: a point of Q represents the entirety of data that defines a quantum system. There is a subspace Q' of Q whose points represent *gapped* quantum systems. In Figure 3, Q' is the subspace enclosed by the yellow curves; the blue curve depicts gapless quantum systems that lie between the gapped ones. Here is the central problem:

Compute the set $\pi_0(Q')$ of deformation classes of gapped quantum systems.

To obtain a meaningful problem, we fix some discrete parameters that describe the system: the dimension d of space, the symmetry group G, etc.

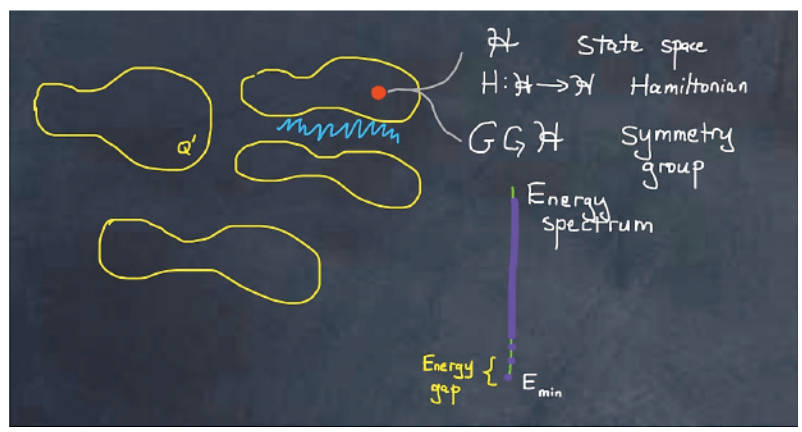


Figure 3. Moduli space of gapped quantum systems

The classic example of deformation classes of quantum mechanical systems is pictured in Figure 4, which describes the state of water at different temperatures and pressures. In this picture, the liquid region is connected by a path to the vapor (gas) region, so the liquid and gas states are in the same deformation class. In this context, a deformation class is called a *phase of matter*. There is a distinct phase: the solid phase (ice). Much more recently, physicists have discovered new phases of matter (unrelated to water): *quantum Hall states*, *topological insulators*, and *topological superconductors*, among others. There is much excitement in both theoretical and experimental circles. Possible robust new materials that exhibit these exotic states of matter would find immediate applications, for example, to quantum computation. Whereas traditionally phases of matter are distinguished by their symmetry structure—the Landau paradigm of phase transitions—these newer phases are differentiated via topological invariants. There are many approaches that have been developed over the past decade.

(Continued on page 13)

The importance of this work led to its being chosen as the topic for the Prospects in Theoretical Physics summer school held at the IAS and Princeton University in July.

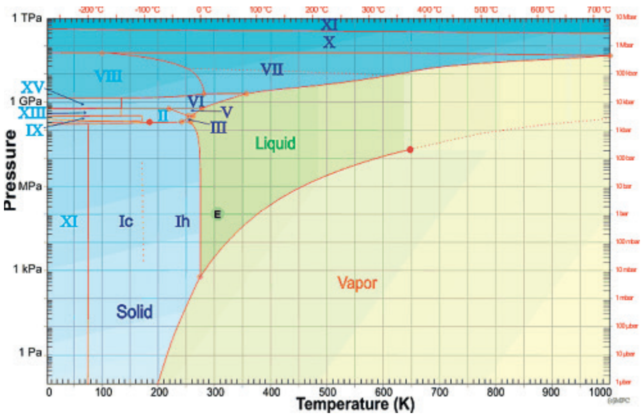
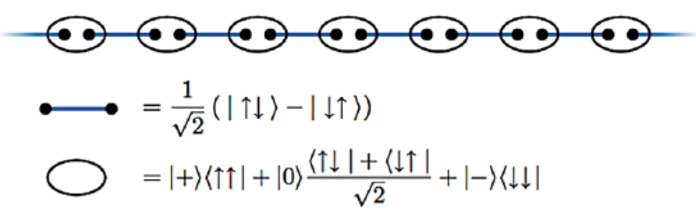


Figure 4. Phase diagram of H_2O

Transition to topological field theory

Intuition from physics suggests that the deformation class of a quantum system is encoded in its *low-energy* behavior. Fluctuations at high energy are not meant to change the topology. This resonates well with intuition from geometry. On a smooth curved space, called a manifold, which is equipped with a notion of distance and angle, one can carry out a generalized Fourier analysis and decompose functions (and differential forms) according to their generalized frequency. Only the functions of lowest frequency—those that are locally constant on the manifold—bear on the large-scale topology; high-frequency functions detect small-scale geometric features. In quantum mechanics, one passes from frequency to energy, which suggests constructing a topological invariant from the low-energy part of a quantum theory.



$$= \frac{1}{\sqrt{2}}(|\uparrow\downarrow\rangle - |\downarrow\uparrow\rangle)$$

$$= |+\rangle\langle\uparrow\uparrow| + |0\rangle\frac{\langle\uparrow\downarrow| + \langle\downarrow\uparrow|}{\sqrt{2}} + |-\rangle\langle\downarrow\downarrow|$$

Figure 5. A simple lattice system

The next step is a big leap. We assume that the low-energy part of the system is well approximated by a quantum *field* theory. This is not such a big leap if the original quantum system is itself a quantum field theory. But the systems of interest are discrete: the degrees of freedom live on a lattice and the Hamiltonian is a discrete sum. (Figure 5 illustrates the discrete nature of lattice systems.) Nonetheless, they often have continuum limits in which the degrees of freedom are *fields*: functions and other familiar objects from smooth geometry. The particular continuum limit we focus on is at low energy, where—without proof—we assume that there is a *scale-independent* quantum field theory. (Links between discrete and continuous quantum systems have been extensively studied by IAS Professor Tom Spencer.) The limit scales out the energy, and what is left has no scale. But now we impose the energy gap condition depicted in Figure 3. It implies that the quantum field theory has much more than scale invariance: it has topological invariance. In other words, it is a *topological field theory*, a particularly tractable species of quantum field theory introduced by IAS Professor Edward Witten in the late 1980s. If we jiggle the original quantum system just a bit, it is reasonable to suppose that this topological field theory also jiggles just a bit. So the topological field theory is a topological invariant of our original system, and can be used to detect if two systems are connected by a path. The intuition from physics suggests this low-energy description should precisely detect the deformation class.

Recall in our toy problem the ordering of the balls (Figure 2) is a complete deformation invariant of gapped configurations. Now for gapped quantum systems we have a concrete proposal for a complete deformation invariant: the low-energy topological field theory.

A mathematical framework for quantum field theory

We are closer to abstracting a mathematical problem from the physics classification question. But now we need to give a mathematical definition of the objects—topological quantum field theories—that we hope to classify. Almost since the beginning of quantum theory, there have been mathematical formulations capturing particular aspects of quantum field theory. In the late 1980s, a geometric axiom system for scale-invariant quantum field theories emerged—many important contributions came from the Oxford school—and in particular topological theories became an object of intense mathematical study. (This geometric axiom system derives from Wick-rotated quantum field theory on compact manifolds and applies as well to scale-dependent theories, but that aspect is much less developed.) Many variations have been studied, particularly including strong forms of locality, and powerful theorems such as the Baez-Dolan-Hopkins-Lurie *cobordism hypothesis* have been proved. This body of mathematics is still under intense internal development, but there are already impressive applications to other parts of mathematics and back to physics.

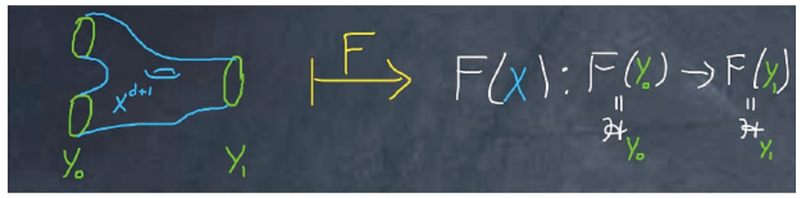


Figure 6. QFT from a bordism point of view

We only need mention here the basic framework, which is depicted in Figure 6. The dimension of space is d, so that of spacetime is $d+1$. On the left of the figure are spaces Y_0 and Y_1 and an evolution X which begins at Y_0 and ends at Y_1. The field theory F outputs linear information from this diagram: vector spaces $\mathcal{H}_0$, $\mathcal{H}_1$ from the spaces, and a linear map $F(X)$ between them from the evolution. This captures the quantum information in a geometric form. In a topological theory, the map F is invariant under deformations of the input data.

The input pictures are familiar in topology: they are *bordisms* as studied by Lev Pontryagin and René Thom in the 1940s and 1950s. This link to bordism goes beyond these pictures in a particular case: if the field theory is not only topological but also *invertible*. The invertibility refers to the natural composition law, which juxtaposes quantum systems. Invertible field theories, even if not topological, are a very special and particularly simple baby case of general quantum field theories, yet they arise in several important mathematical and physical contexts. My collaborators Michael Hopkins, Constantin Teleman, and I observed that for invertible topological theories the map F can be interpreted in the world of *stable homotopy theory*, an important and highly developed branch of topology. The key point is that bordisms depicted in Figure 6 have a moduli space that resides in stable homotopy theory—an "infinite loop space." This particular bordism space is closely related to that introduced by Thom, and in fact is precisely the bordism space studied by Galatius-Madsen-Tillmann-Weiss (with mathematical motivations completely divorced from applications to physics).

Short-range entanglement and stable homotopy theory

We have already seen that *gapped* quantum systems, in particular gapped lattice systems, may have low-energy *topological* field theory approximations. The single hypothesis of a gap already makes possible the application of powerful mathematics. A second hypothesis—*short-range entanglement* as defined by Alexei Kitaev, Xiao-Gang Wen, and other condensed matter physicists—implies that the low-energy topological theory is *invertible*. One facet is the uniqueness of the ground state of the system on any compact space. Many gapped systems of interest satisfy this additional strong constraint. For these systems, our arguments show that the classification of phases becomes a question in stable homotopy theory! The techniques developed over many years by topologists—generalized cohomology theories, the Adams spectral sequence, and much more—are now brought to bear on specific computations of interest in physics: the computation of $\pi_0 Q'$ for particular moduli spaces Q' of gapped quantum systems. Many computations have already been done and others are in progress. In ongoing work with Hopkins, we implement unitarity in this context and obtain strong agreement with a different approach to topological phases due to Kitaev, who arrives at stable homotopy theory directly from lattice systems. Work of Anton Kapustin and collaborators arrives at similar answers. Much work remains to reconcile the different viewpoints.

I have outlined the main ideas, which, in one approach, lead from phases of complicated quantum systems to problems in stable homotopy theory. I want to emphasize one of the key ingredients: the mathematical framework for quantum field theory depicted by the image in Figure 6. It has bordism built in and for that reason leads in the invertible case to bordism spaces in topology. It allows us to tackle the quantum physics problem head-on: with a geometric definition of a quantum field theory, we can directly classify these quantum systems with few inputs—dimension, symmetry group, etc. The success of this mathematical framework in this classification problem gives some hope that it captures essential features of scale-dependent quantum field theories as well, a topic for future investigations. ■

Recommended Viewing: Is the abstract mathematics of topology applicable to the real world? Topology is the only major branch of modern mathematics that wasn't anticipated by the ancient mathematicians. Throughout most of its history, topology has been regarded as strictly abstract mathematics, without applications. However, illustrating Eugene Wigner's principle of "the unreasonable effectiveness of mathematics in the natural sciences," topology is now beginning to come up in our understanding of many different real-world phenomena. In a mini-symposium organized in May, Robert MacPherson, Hermann Weyl Professor in the School of Mathematics, described the history and pervasiveness of topology, Raúl Rabadán described how topology modifies our understanding of evolution and disease, and Randall Kamien discussed the relationship between topology and liquid crystals, like those in computer displays. Videos of the talks are available at https://video.ias.edu/mini-symposium-topology-2015.

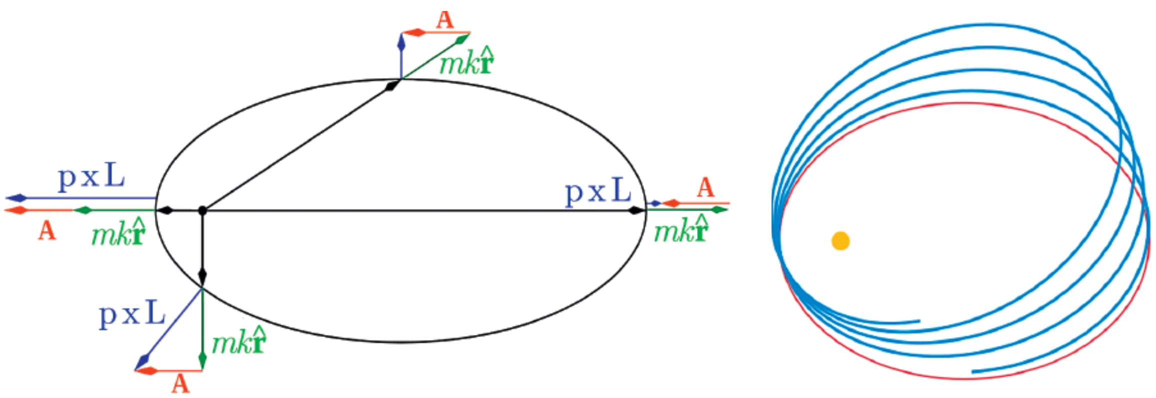
From the Motion of Planets to Quantum Field Theory

The hidden symmetries of orbits, energy levels, and elementary particle interactions

BY JOHANNES M. HENN

What do the motion of the planets in our solar system, the energy levels of the hydrogen atom, and the interactions between subatomic particles have in common? Surprisingly, they are all governed by the same hidden symmetry principles. This is what Simon Caron-Huot (now Assistant Professor at the Niels-Bohr Institute, Copenhagen) and I found in recent work done as Members at the Institute.

Symmetry is a very important notion in physics, for mainly two reasons. On the one hand, systems with a lot of symmetry are usually easier to solve and study, so that key properties can be understood analytically. On the other hand, and more fundamentally, in the development of physics, symmetry principles have often been a successful guiding principle toward theories relevant for describing nature. An example is Einstein's equivalence principle that led to the development of general relativity.



FIGURES ADAPTED FROM WIKIPEDIA

Thanks to the conservation of the Laplace-Runge-Lenz vector A (in red) for the two-body Kepler problem, orbits are closed (left image). In systems where the conservation is only approximate, the elliptical orbits precess, meaning the orientation of the ellipses does not change (right image).

What is the hidden symmetry underlying the motion of the planets, such as the Sun and the Earth? The answer to this question is important for the Kepler problem, i.e., the question of how to predict the position and velocity of two bodies, given some initial conditions. (It should be noted that physicists often use the word "problem" not in the standard meaning, which has a negative connotation; rather, it should be thought of in a positive sense, as an interesting challenge.) The motion is governed by Newton's laws, which tell us, in particular, that the gravitational force between two objects depends only on their relative distance. From this, it follows that the orbits lie in a plane. However, observing the trajectories more closely, one sees that they form ellipses that do not precess with time. In other words, the orientation of the ellipses does not change, and hence the orbits are closed. This regularity is a hint for a hidden symmetry, which in turn implies a constant of motion. Indeed, a certain vector, named after Laplace-Runge-Lenz (LRL), does not change with time (see figure).[1] It points toward the perihelion of the ellipse, i.e., the point of the orbit where the Earth comes closest to the Sun, and its conservation explains the regularity of the orbits that we observe.

WITH SO MANY POSSIBILITIES FOR DISCUSSIONS, IT IS HARD TO REMEMBER HOW EXACTLY SIMON AND I BEGAN WORKING TOGETHER, BUT IT WOULD NOT SURPRISE ME IF OUR PROJECT STARTED SOMEWHERE BETWEEN TEA TIME OR A GAME OF TENNIS AT THE IAS COURTS.

This is an example where the laws of nature have an exact symmetry. This often allows one to understand the properties of a theory better, or to perform exact calculations. Sometimes symmetries are only approximate, but can still be very useful. In the present example, the symmetry is broken by other effects, such as gravitational interactions with other planets or corrections coming from general relativity. Whenever the latter can be treated as a perturbation, the exact solution based on the symmetry is a good starting point for the description of the full system.

At atomic scales (when describing molecules, for example), classical mechanics needs to be replaced by quantum dynamics, which was developed in the first part of the twentieth century. The hydrogen atom, consisting of a positively charged proton and a negatively charged electron, can be thought of as the quantum mechanical version of the Kepler problem. In quantum mechanics, positions and momenta are replaced by operators (or matrices) that in general do not commute—this is related to Heisenberg's uncertainty principle, which says that the position and the velocity of a particle cannot be known at the same time. A quantum dynamical system is described by a so-called Hamiltonian, whose eigenvalues are the allowed energy levels. It turns out that a suitable quantum version of the LRL vector commutes with the Hamiltonian, meaning it is a conserved quantity in quantum mechanics. This fact was famously used in the early days of quantum mechanics by Wolfgang Pauli to compute the spectrum of the hydrogen atom,[2] in agreement with earlier experiments. The fact that this calculation could be done even before quantum mechanics was fully developed, meaning before the discovery of the Schrödinger equation, further emphasizes the usefulness of the symmetry.

Going to subatomic scales, quantum mechanics, which describes a system with a fixed number of states, is no longer adequate. This can be understood intuitively by Einstein's famous equation stating the equivalence of energy and matter. At high enough energies, particles can be produced and annihilated. Quantum field theory (QFT), developed in the second part of the twentieth century, is appropriate to describe such systems. Its Feynman diagrams can be used to visualize how particles interact with each other.

The so-called Standard Model of elementary particles is based on a specific QFT called quantum chromodynamics (QCD). It is used to successfully describe properties and interactions of elementary particles such as electrons, photons, quarks, and gluons. The discovery of the Higgs boson at the Large Hadron Collider (LHC) at CERN was made possible, on the theoretical side, by predictions of this theory.

Quantum field theory, and in particular QCD, is very complicated, and only in very special cases can exact solutions be obtained. One might ask whether there is an idealized version of QCD that is the analogue to the hydrogen atom in quantum mechanics, in the sense that it can be exactly solved. When looking for such a special quantum field theory, a natural question is whether the LRL symmetry can be transferred to quantum field theory.

First hints can be gleaned from a model for electron-proton bound states analyzed by Richard Cutkosky and Gian Carlo Wick (Member 1953) in the 1950s.[3] Their model, based on a certain approximation that keeps only subsets of Feynman diagrams, indeed has an extra symmetry that can be traced back to the LRL vector. However, the approximation they used is an ad hoc one and neglects important multi-particle effects, for example. This leads to the question of whether this model could be embedded in a fully consistent quantum field theory.

The answer to this question arose while studying a supersymmetric version of QCD called N=4 Super Yang-Mills. This theory was previously found to have an unexpected hidden symmetry, dubbed dual conformal symmetry, in the so-called planar limit, where only planar Feynman diagrams are kept. This can be done in a consistent way. Simon and I considered hydrogen-like bound states of two massive particles within this theory, similar to the ones considered by Cutkosky and Wick, but including multi-particle interactions. We showed that the dual conformal symmetry is directly related to the classical LRL symmetry.[4]

Just like in the Kepler and hydrogen examples, the symmetry helps simplify calculations dramatically. We were able to use the latter to map the calculation of the bound-state energy levels to a much simpler situation. This makes the problem amenable to powerful integrability techniques that were recently developed and that are applicable even in the strongly coupled regime. This constitutes an important step toward the first analytic solution of a bound-state problem in a four-dimensional Yang-Mills theory.

This research also suggests a number of interesting questions:

- Is N=4 Super Yang-Mills the unique quantum field theory having an LRL symmetry?
- Is there a generalization of this symmetry to non-planar corrections?
- In quantum mechanics, with hindsight, it is possible to choose variables that make the LRL symmetry obvious by rewriting the Kepler problem as a four-dimensional harmonic oscillator. Is there a reformulation of quantum field theory that makes the hidden symmetry manifest?

In a broader context, N=4 Super Yang-Mills can be thought of as a toy model of QCD. It is a toy model not in the sense of particle phenomenology but for the complicated calculations necessary to make predictions from quantum field theory.

(Continued on page 15)

Originally from Germany, Johannes M. Henn started his academic career in France. He graduated from École Normale Supérieure de Lyon in 2005 and completed a Ph.D. in theoretical particle physics at Laboratoire d'Annecy-le-Vieux de Physique Théorique in 2008. After a first postdoctoral research period at Humboldt University Berlin from 2008 to 2011, he came to the IAS as a Member in 2011 until 2015. He recently accepted a full professorship at Johannes Gutenberg University Mainz, Germany. This article is based on a talk that he gave at a Friends of the Institute lunch in the spring.

Geometric Langlands, Khovanov Homology, String Theory

Edward Witten on rich mathematical secrets and surprises

In 2006, Edward Witten, Charles Simonyi Professor in the School of Natural Sciences, cowrote with Anton Kapustin a 225-page paper, "Electric-Magnetic Duality and the Geometric Langlands Program," on the relation of part of the geometric Langlands program to ideas of the duality between electricity and magnetism.

Some background about the Langlands program: In 1967, Robert Langlands, now Professor Emeritus in the School of Mathematics, wrote a seventeen-page handwritten letter to André Weil, a Professor at the Institute at the time, in which he proposed a grand unifying theory that relates seemingly unrelated concepts in number theory, algebraic geometry, and the theory of automorphic forms. A typed copy of the letter, made at Weil's request for easier reading, circulated widely among mathematicians in the late 1960s and 1970s, and for more than four decades, mathematicians have been working on its conjectures, known collectively as the Langlands program.

Witten spoke about his experience writing the paper with Kapustin and his thoughts about future directions in mathematics and physics in an interview that took place in November 2014 on the occasion of Witten's receipt of the 2014 Kyoto Prize in Basic Sciences for his outstanding contributions to mathematical science through his exploration of superstring theory. The following excerpts are drawn from a slightly edited version of an interview conducted by Hirosi Ooguri, Member (1988–89) and Visiting Professor (2015) in the School of Natural Sciences, which was published in the May 2015 issue of Notices of the American Mathematical Society *(www.ams.org/notices/201505/rnoti-p491.pdf).*[1]

DAN KOMODA

Edward Witten at the 2013 Prospects in Theoretical Physics Program at the Institute

It was very hard to write a paper about it. It took about a year. For that year, I felt like someone who had discovered the meaning of life and couldn't explain it to anybody else. And in a sense, I still feel that way for the following reason. Physicists with a background in string theory or gauge theory dualities can understand my paper with Kapustin on geometric Langlands, but for most physicists, this topic is too detailed to be really exciting. On the other hand, it is an exciting topic for mathematicians but difficult to understand because too much of the quantum field theory and string theory background is unfamiliar (and difficult to formulate rigorously). That paper with Kapustin may unfortunately remain mysterious to mathematicians for quite some time.

FOR THAT YEAR, I FELT LIKE SOMEONE WHO HAD DISCOVERED THE MEANING OF LIFE AND COULDN'T EXPLAIN IT TO ANYBODY ELSE. AND IN A SENSE, I STILL FEEL THAT WAY. . .

I think it's actually very difficult to see what advance in the near term could make the gauge theory interpretation of geometric Langlands accessible for mathematicians. That's actually one reason why I'm excited about Khovanov homology. My approaches to Khovanov homology and to geometric Langlands use many of the same ingredients, but in the case of Khovanov homology, I think it is quite feasible that mathematicians could understand this approach in the near future if they get excited about it. I believe it will be more accessible. If I had to bet, I think I have a decent chance to live to see gauge theory and Khovanov homology recognized and appreciated by mathematicians, and I think I'd have to be lucky to see that in the case of gauge theory and the geometric Langlands correspondence—just a personal guess.

A lot of things that number theorists like have appeared in physics, and some have even appeared in my own work. Plenty has been found to show that the physics theories that we work on as string theorists are interesting in number theory. These theories know something about number theory, but personally I don't see an opportunity to really make contact in a structural way with number theory in the foreseeable future. I can't even formulate what it would mean to make such contact, so I can't even properly tell you what we can't do, but I think the time is not right to do it.

Anyway, that's why I personally concentrated on geometric Langlands rather than on number theory, and geometric Langlands was hard enough. It was a lot of work to understand it, but I think that having understood it, many things that mathematicians do involving geometric aspects of representation theory are much more accessible as part of physics. . . . In the last few years physicists working on supersymmetric gauge theories in four dimensions and their cousins in six dimensions have made several discoveries involving the role of conformal field theory at the critical level, so the time may well be right to resolve this point.

In the last twenty years, not only has this interaction of math and physics continued to be very rich, but it has developed in such diversity that very frequently exciting things are done which I myself am able to understand embarrassingly little about, because the field is expanding in so many directions.

I am sure that this is going to continue and I believe the reason it will continue is that quantum field theory and string theory, I believe, somehow have rich mathematical secrets. When some of these secrets come to the surface, they often come as surprises to physicists, because we do not really understand string theory properly as physics—we do not understand the core ideas behind it. At an even more basic level, the mathematicians are still not able to fully come to grips with quantum field theory and therefore things coming from it are surprises. So for both of those reasons, I think that the physics and math ideas generated are going to be surprising for a long time.

I think there are definitely exciting opportunities for young people to come and help explain what it all means. We don't understand this properly. We got a wider perspective in the 1990s when it became clear that the different string theories are unified by nonperturbative dualities and that string theory in some sense is inherently quantum mechanical.

But we're still studying many different aspects of a subject whose core underlying principles are not clear. As long as that is true, there are opportunities for even bigger discoveries by today's young people. But if I could tell you exactly what direction you had to go in, I would be there. ■

1 The interview originally appeared in the December 2014 issue of *Kavli IPMU News*, the news publication of the Kavli Institute for the Physics and Mathematics of the Universe (Kavli IPMU) of the University of Tokyo, and was conducted by Kavli IPMU's Principal Investigator Hirosi Ooguri, Fred Kavli Professor of Theoretical Physics and Mathematics and Founding Director of the Walter Burke Institute for Theoretical Physics at the California Institute of Technology.

MOTION OF PLANETS *(Continued from page 14)*

For example, theoretically describing collider experiments, such as the ones being conducted at the LHC, requires scattering amplitudes that can be computed from QFT. Studying the supersymmetric model already has led to numerous important insights and new techniques. This line of research continues to be a very rich enterprise, constantly unveiling new surprises about quantum field theory and new tools for performing QCD calculations that are relevant for LHC physics.

A concrete recent example of this has to do with the notoriously difficult Feynman integrals appearing in perturbative QFT. A key idea, developed by IAS Professor Nima Arkani-Hamed and his collaborators, is that the singularity structure of the Feynman integrand can be used to predict properties of the integrated answer.[5] Through discussions with Nima, and playing with examples, I realized that many of the concepts could be applied beyond N=4 Super Yang-Mills. This led me to propose a new method for computing Feynman integrals that is by now widely used.[6]

The IAS is one of the few places in the world where postdoctoral researchers find an ideal environment for research without teaching obligations, deadlines, and so on. Indeed, not being constrained to follow a specific, predetermined research program is crucial for making new, unexpected discoveries. Perhaps the IAS could be compared to a parallel universe, or a protective bubble, where speculative new ideas can be developed and strengthened to the point where they can survive the harsh real world outside. This was certainly the case for the new techniques I just mentioned.

I greatly enjoyed the many opportunities to discuss my research with other IAS Members and Faculty at lunch, in the wonderful discussion areas in Bloomberg Hall, at tea, and elsewhere on the IAS campus. With so many possibilities for discussions, it is hard to remember how exactly Simon and I began working together, but it would not surprise me if our project started somewhere between tea time or a game of tennis at the IAS courts. ■

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2 W. Pauli, *Z. Phys.* 36, 336 (1926).

3 G. C. Wick, *Phys. Rev.* 96, 1124 (1954); R. E. Cutkosky, *Phys. Rev.* 96, 1135 (1954).

4 J. M. Henn and S. Caron-Huot, *Phys. Rev. Lett.* 113 (2014) 16, 161601.

5 N. Arkani-Hamed, J. L. Bourjaily, F. Cachazo, J. Trnka, *JHEP* 1206 (2012) 125.

6 J. M. Henn, *Phys. Rev. Lett.* 110 (2013) 25, 251601.

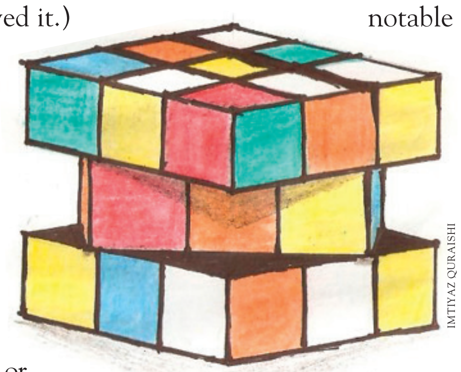
Permutation Puzzles: From Archimedes to the Rubik's Cube

How many moves would God, or a supercomputer, take to solve every position?

BY MATTHEW KAHLE

The Rubik's Cube is one of the most popular toys in history. It is also an example of a permutation puzzle, which have existed in mathematics in one form or another for at least 140 years. In hindsight, it is strange that the cube ever became so popular considering how hard it is. Very few ever solved it, and far fewer without a book or website as guide. (To his credit, the Hungarian professor of architecture who invented the cube took a few weeks but solved it.)

It might be surprising that more than thirty years after the 1982 craze, people are still discovering new things about the Rubik's Cube. For example, mathematician Morley Davidson (Member 1995–96) and Tomas Rokicki recently showed that God's number of the Rubik's Cube is twenty-six. Their proof depends on a supercomputer calculation.



IMTIYAZ QURAISHI

There is an almost inconceivably large number of positions for the cube—roughly 43 billion billion (4.3×10^{19}). Although this number is enormous, it is finite, so there has to be in some sense "a worst-case scenario," a position that is maximally mixed up.

The God's number of the Rubik's Cube is how many moves God, or a supercomputer, would take to solve it from this maximally mixed-up position.

What has been known for several years is that there are a few positions that require twenty-six moves to solve. The only known example is the "superflip composed with fourspot," together with its rotations. The remarkable result of Davidson and Rokicki is that twenty-six moves suffice to solve every position.

For the last several years, we have had optimal solvers that can solve any given Rubik's Cube position in the minimum number of moves, say in less than a second, on your desktop computer. So it might seem like this should resolve the question, with just brute force. Use these solvers to compute the minimal number of moves for every possible position, and then take the maximum over all of them, and you know the worst-case scenario. The problem is that there are 43 billion billion positions. So even if you could compute optimal solutions for, say, a million positions in one second, it would still take over a million years before you had calculated it for all of them.

Davidson and Rokicki discovered a number of clever reductions, greatly reducing the number of positions to check to only a few billion positions. Then roughly thirty-two CPU-years of donated time at the Ohio Supercomputer Center finished the computation in a matter of days.

Matthew Kahle, Member (2010–11) in the School of Mathematics and Associate Professor at the Ohio State University, is interested in interactions of topology and geometry with probability, statistical mechanics, and combinatorics.

Permutation puzzles are older than the Rubik's Cube, and perhaps ancient. For one notable example, the familiar "15-puzzle," where one slides square pieces around in a grid, went through a craze in the United States in 1880, almost exactly a hundred years before the Rubik's Cube craze.

Sam Loyd, who has been called "puzzledom's greatest celebrity . . . popularizer, genius" as well as a "huckster . . . and fast-talking snake oil salesman," later further popularized the 15-puzzle by offering a prize of $1,000 to anyone who could find a sequence of moves that switch the 14 and 15. He must have been confident that it was impossible. He may have even known that this was a theorem already proved by mathematicians Wm. Woolsey Johnson and William E. Story in 1879.

The most ancient puzzle we know of that depends on permuting geometric pieces is probably the Stomachion. The Stomachion is a dissection of the square into fourteen convex pieces. Once taken apart, reassembling them into a square shape can be quite challenging.

The Stomachion caught the attention of the greatest mathematician of the ancient world, Archimedes, who wrote a treatise on the puzzle. This treatise was lost, but then recently part of it was recovered in a palimpsest. Archimedes asks for the number of distinct ways to reassemble the fourteen pieces into a distinct shape. If Archimedes gave us the answer, this was lost. However, mathematician Bill Cutler was able to compute the number of possible solutions to be 17,152, with the help of a computer. If Archimedes was able to do this calculation, how he did it remains a mystery. ■

National Math Festival: Supporting the Math of Today and Tomorrow

The Institute was invited by the Mathematical Sciences Research Institute to cosponsor and promote the country's first National Math Festival, a three-day celebration held April 16–18 in Washington, D.C., to encourage and support the math of today and tomorrow.

Mario Draghi, President of the European Central Bank and Institute Trustee since 1998, opened the weekend by discussing the importance of long-term investments in education and basic research:

> To believe in basic research is to believe in the future.... It is difficult to foresee where the next big and small wave of technological innovation will come from. What we know is that it will spring out of an environment where there is a burning desire to expand knowledge, both at the theoretical and experimental levels—an environment where fundamental research in math, and more generally science, is the highest priority of program design.

Marilyn and James Simons, Vice Chairman of the Institute's Board—whose Simons Foundation provided generous support to the festival, along with Carnegie Corporation of New York, Google, and the Charles and Lisa Simonyi Fund for Arts and Sciences, among others—were present throughout the activities, which included a congressional briefing with Senators Lamar Alexander, Al Franken, Patty Murray, Harry Reid, Chuck Schumer, and Congresswoman Nancy Pelosi, Democratic Leader of the U.S. House of Representatives.

Following a broad-reaching talk on the returns on basic research by Eric Lander, co-chair of the President's Council of Advisors on Science and Technology, Institute Board Chairman Charles Simonyi discussed his personal support of and experiences with basic research's exponential reach.

The festival included a forum on building the profession of math teachers in America and a free day-long public showcase of more than seventy exhibitions, performances, and lectures, attended by tens of thousands of visitors. The public turnout for the event was overwhelming and enthusiastic—the audience for a talk on the secrets of the Rubik's Cube by Matthew Kahle, Member (2010–11) in the School of Mathematics, was standing room only (see article above).

The festival was a testament to the potential of the larger research community to influence the nation's priorities when it comes to supporting the importance of mathematics.

PHOTO CREDITS, L TO R: KEITH LANE, KEITH LANE, AMANDA KOWALSKI, AMANDA KOWALSKI




From left: Senator Chuck Schumer with Robbert Dijkgraaf; Marilyn and James Simons with Senator Harry Reid (center); Charles Simonyi (right) with MSRI Chairman Roger Strauch; Mario Draghi

 (Continued from page 1)

basketball. He gravitated to kids who were a little older, bolder, and who occasionally got into trouble, petty theft, but no violence to my knowledge. In my hometown, junior high school was a pivotal point in the lives of many poor and not so poor, black, brown, and working class kids from many diverse backgrounds.

By the time I entered high school and then college, I had not seen nor heard about Emery in years, until one day during the summer between my junior and senior years of college I heard and read about his shooting by a Pelham police officer. Pelham Manor is a relatively affluent bedroom community just north of the Bronx with a much smaller black population than the nearby towns of New Rochelle, Mount Vernon, or Yonkers. Emery was eighteen years old when he was shot on July 19, 1979.

According to both police and newspaper reports, Emery was driving a car into Pelham when he was stopped by a police officer on the suspicion of driving a stolen vehicle. Officer John B. Robbins claimed in court and police deposition that he had attempted to arrest Emery, but Emery broke free and ran away from him. After ordering him to stop and unable to chase him across a church parking lot, the officer fired a warning shot into the air and when Emery kept running, fired a shot into the young man's back. Then and now, I can envision Emery in all his youth, athleticism, and long legs, creating distance between himself and the police officer, until the bullet felled him, in the parking lot of a church.

HOW DOES IT FEEL TO BE A THREAT? HOW DOES IT FEEL TO KNOW THAT YOUR LIFE IS LESS VALUED? HOW DOES IT FEEL TO KNOW THAT THERE ARE PEOPLE IN YOUR MIDST WHO FEEL AND ARE MORE PRIVILEGED THAN YOU BY THE ACCIDENT OF PHENOTYPE?

During the subsequent trial, Robbins claimed that he saw a shiny instrument in Emery's hands, which made him fearful for his life. Emery did, in fact, have something in his hand at the moment he was shot. It was the keys to the car he was driving. I do not know whether Emery was, in fact, driving a stolen vehicle. We do know, however, that the police ballistics expert who testified during the trial stated that he found nitrite particles on the back of Emery's shirt, which was consistent with someone who was shot in the back.

An image of Emery from my junior high school basketball team came to mind as I was preparing this brief article, so I decided to begin with him in remembrance, not only of his life, but the thousands of black and brown youth, women, and men, who have ended up at the intersection of white anxiety, state power, and spatial segregation. My goal is not to personalize or gain some vicarious access to the shock, furor, and horror over the deaths of Eric Garner, Oscar Grant, and Michael Brown, but to remind or inform readers that these recent killings are all too common in black and brown communities among societies that have developed robust economies built on slave and poorly remunerated labor.

In the aftermath of slavery and abolition, disproportionately high levels of unemployment and incarceration rates, poor education, spatial segregation, and capricious doses of state violence structure the conditions of marginality that make violence against these populations not only plausible but banal. These structuring conditions affect labor markets and access to education, professional and personal networks, friends, mates, and lovers—economies in the fullest sense of the term. Black and brown members of the middle class and even the elite in various societies have experienced racially coded harassment and state and para-state violence as they walk, talk, shop, and drive, part of a larger pattern and history of formal and informal institutional racism.

Well before 9/11 in the United States and recurrent terrorist attacks in the European Union beginning in the 1990s, populations ranging from the Maghrebi in France, blacks and Latinos in the United States, and *Afrodescendentes* in Colombia and Brazil have been considered, in various ways, threats to national and local security. Ferguson, Missouri, which exploded on national and international media last summer, provided a glimpse of the black experience in the United States rarely encountered, much less remembered, by the bulk of the U.S. population. Most black and brown people I know, whether in the United States, Brazil, France, Colombia, Britain, or many other nation-states, have an Emery Robinson in their lives. Most whites, with the exception of those who have intimate relations with black and brown people in predominantly white societies, do not have an Emery Robinson in their memories. Recalling a passage from the writings of the Argentine writer Jorge Luis Borges, *we are our memories*.

France: The *Charlie Hebdo* attacks in France earlier this year have helped highlight the legacies of discrimination and exclusion of French nationals of African descent. In October–November 2005, largely immigrant communities in northeast Paris rioted in response to the deaths of two youths of North African origin who were electrocuted in an electricity substation after being chased by the police. This led to rioting in Paris suburbs and in various parts of France, underscoring the precarious relations between the police and Maghrebi/North African communities. When the unrest escalated and spread to other cities, the French government introduced emergency measures to try to restore order. Nicolas Sarkozy, former prime minister and interior minister in 2005, referred to the two youths as thugs, and the rioters in the suburbs as the scum of French society.

Brazil: In Brazil, research conducted by the Instituto de Pesquisa Economia Aplicada determined in 2013 that black and brown male (*não-branco, negro*) youth are 3.7 times more likely to die violently. Two of every three people assassinated in Brazil are black men, and blacks have a higher incidence of experiencing police aggression (6.5 percent) compared to whites (3.7 percent). Brazil has one of the highest rates of youth killings by police in the entire world. Scholars such as Almir de Oliveira Júnior and Verônica Couto de Araújo Lima have concluded that to be *negro no Brasil* means to be at risk, living in a state of public insecurity. A recent incident in Rio de Janeiro provides a graphic example of the extinguished lives embedded in this statistic. On February 21, three boys were standing on a street corner, two on bicycle, in Favela de Palmeirinha, a neighborhood in the Baixada Fluminense of Rio de Janeiro, joking around, recording each other's gestures with their cell phones. A police car drove by and, without warning, police officers began firing gunshots at the three boys. Two were wounded, one mortally. Predictably, the police account claims that the boys were shot in an exchange of gunfire. The phone of the dead boy, which kept recording while he lay on the ground, told a different story of adolescents simply being adolescents. The boy who survived a gunshot wound to his left arm and stomach also recorded the incident on his cell phone. According to reports, there is no evidence of a weapon of any sort in the possession of any of the boys, other than the claims made by police officers in the police report. "Exchange of gunfire" is common phrasing by police in these situations to justify their brutality on the streets of Rio, to be more specific, in the *favelas* of Rio.

Colombia: In Colombia, scholars of public health have discovered that ethno-racial identification is a social determinant of public health. In the city of Cali, for example, *Afrodescendentes* are more likely to die violently and prematurely than the total population in the Cauca Valley (17.8 vs. 8.8 percent) and in Cali (63.8 vs. 56.1 percent). Fernando Urrea-Giraldo, Gustavo Bergonzoli Pelaez, and Victor Hugo Muñoz Villa describe the production mechanism for social phenomena as the dynamic interaction between phenotype (external appearance) and genotype (resistance and susceptibility) to attenuate or minimize physical, social, chemical, and biological characteristics of individuals, making them more or less susceptible to various diseases.

How do we make sense of the history of gendered, racialized violence in societies that have transitioned from slave labor to industrial and in some instances post-industrial and increasingly technological economies? Although the techniques and technologies of violence and surveillance have certainly changed, amplified, and transformed over the past several hundred years, perhaps it is the assumptions and symbolic associations that have not changed over these years. In societies such as Colombia, France, the United States, and Brazil, police officials often have difficulty considering blacks and members of other non-white minority groups as victims of crime or as law-abiding citizens because of the construction of suspicion and assumptions of their criminality.

To reiterate, it is important to situate these practices in a comparative, multinational framework. These and other instances are empirical examples of what I have referred to as racial regimes, which encompass negative identification, state and popular surveillance, and coercion, coupled with exclusion from preferred dimensions of society and polity: education and employment. One of the key ideational components of racial regimes is the construction of suspicion, deployed not only by representatives of state, but by common citizens who have also been socialized to believe that black and brown populations represent dangers to the public good, to the public sphere.

How does it feel to be a threat? How does it feel to know that your life is less valued? How does it feel to know that there are people in your midst who feel and are more privileged than you by the accident of phenotype? How can the privileged be made to understand that it is the most feared members of the national population who are among the most vulnerable? For those interested in global public health and being a responsible citizen in so many different countries, the answers to these questions begin with empathy and have—thank goodness for so many enraged and organized youth—resulted in politics.

Now would be a good time for anti-racist activists in various parts of the world to compare notes and confer with each other in virtual and real space across national and regional boundaries, to force national governments and multinational organizations to acknowledge the transnational dimensions of this phenomenon. Hopefully, transnational mobilization can serve as a call to action against racist state violence in various parts of the world. ■

Michael Hanchard, Member (2014–15) in the School of Social Science, is the Society of Black Alumni Presidential Professor in the Political Science Department of Johns Hopkins University and a founding Director of the Racism, Immigration, and Citizenship Program. His research and teaching interests combine a specialization in comparative politics with an interest in contemporary political theory, encompassing themes of nationalism, racism and xenophobia, and citizenship. This article first appeared on the Huffington Post.

where she leaves an indelible and powerful legacy."


ANDREA KANE

Patricia Crone with a Member in 2011

> *Islam arose with remarkable speed and mystery. Patricia Crone's well-stocked mind, clear prose, and unflinching intellectual honesty were devoted to explaining why. . . . That required both personal and intellectual bravery. The central beliefs of Islam, such as the way the Koran took shape, the life of Muhammad, and Islam's relations with other religions, are sensitive subjects. Outside scrutiny can make tempers flare, especially when the conclusions are expressed in a witty and sardonic style. . . . Crone's steely blue eyes and steelier brain shunned any temptation to turn to safer topics, or to cloak her critiques of Islamic tradition in the jargon used by more cautious scholars. She simply refused to treat the Arabs as an exception to the normal rules of history; and something was badly wrong in Islamic studies, she said, if she had to justify that.*
>
> —The Economist, *www.ias.edu/economist-crone*

Born in Kyndeløse, Denmark, on March 28, 1945, Crone studied at the University of Copenhagen before completing both her undergraduate education (1969) and Ph.D. (1974) at the School of Oriental and African Studies at the University of London. Upon earning her Ph.D., Crone became Senior Research Fellow at the University of London's Warburg Institute. In 1977, she accepted a position as University Lecturer in Islamic History and Fellow of Jesus College at the University of Oxford, where she taught for thirteen years. Following her time at Oxford, Crone moved to the University of Cambridge and served as Assistant University Lecturer in Islamic Studies and Fellow of Gonville and Caius College from 1990–92, after which she was University Lecturer until 1994. Crone was then University Reader at Cambridge until 1997, when she joined the Faculty of the Institute.

Crone's first book, *Hagarism: The Making of the Islamic World* (Cambridge University Press, 1977), written with Michael Cook, had a profound impact on the study of the early centuries of Islam, probably more than any other contribution to the field. Departing from the earlier studies of Ignaz Goldziher and Joseph Schacht on the traditions about the Prophet Muhammad (ḥadīth), and influenced by the work of John Wansbrough on the history of the canonization and transmission of the Qur'ān, the authors challenged the prevalent scholarly consensus on the historical value of the Muslim sources pertaining to the early history of Islam and looked instead at archaeological findings and contemporary non-Muslim (e.g., Greek and Syriac) accounts on the origins and formative period of Islam. The book received mixed reviews at the time—harsh criticism as well as praise—but eventually led to a far more refined and sophisticated approach in modern scholarship to the study of early Islamic history. Today it is considered a milestone in the scholarly investigation of the formative period of Islam.

This was followed by work that closely related to her doctoral thesis, resulting in two books—*Slaves on Horses: The Evolution of Islamic Polity* (Cambridge University Press, 1980) and *Roman, Provincial, and Islamic Law* (Cambridge University Press, 1987)—in which Crone deftly explores tribes and tribal culture in early Islam and investigates Roman, provincial, and Islamic law and their connections to Near Eastern legal systems. Crone's groundbreaking *Meccan Trade and the Rise of Islam* (Princeton University Press, 1987) challenged the widely accepted understanding of Mecca as a major trade center and presented a powerful perspective on the beginnings of Islam.

Pre-Industrial Societies: Anatomy of the Pre-Modern World (Oxford University Press, 1989), recently republished in spring 2015, provides a lucid and engaging account of pre-industrial societies, ranging from the Far East to the Indian sub-continent, to the Islamic societies of the Near East and North Africa. The topic grew out of Crone's courses in Islamic history, as she saw a need for clarity on the motivations, differences, and impact of industrialization on diverse cultures and societies.

In *God's Rule: Government and Islam; Six Centuries of Medieval Islamic Political Thought* (Columbia University Press, 2004), which earned the British-Kuwait Friendship Prize in 2005, Crone delivered a broad survey of Islamic political thought in the six centuries from the rise of Islam to the Mongol invasions. Her most recent book, *The Nativist Prophets of Early Islamic Iran: Rural Revolt and Local Zoroastrianism* (Cambridge University Press, 2012), explores the Iranian response to the Muslim penetration of the Iranian countryside, the revolts subsequently triggered there, and the religious communities that these revolts revealed. Peter Brown, in *The New York Review of Books*, noted, "[Crone] has given a voice to a hitherto silent land, which had been as distant from the classical world as were the kingdoms of Axum and Himyar." The highly influential book was recognized with four major awards, including the Albert Hourani Book Award, which recognizes outstanding publishing in Middle East studies; the Houshang Pourshariati Iranian Studies Book Award, for outstanding publishing in Iranian studies; the Central Eurasian Studies Society Book Award, for important contributions to Central Eurasian studies; and the James Henry Breasted Prize, awarded by the American Historical Society for the best book in English, in any field of history prior to C.E. 1000.

A festschrift, *Islamic Cultures, Islamic Contexts: Essays in Honor of Professor Patricia Crone* (Brill/Leiden, 2014), edited by Behnam Sadeghi, Asad Q. Ahmed, Adam Silverstein, and Robert Hoyland, examined Crone's strong and uncompromising character as a scholar and her deep and varied impact on Islamic and Iranian studies. Three volumes of Crone's *Collected Studies*, "The Qur'ānic Pagans and Related Matters," "The Iranian Reception of Islam: The Non-traditionalist Strands," and "The Ancient Near East and Islam," are forthcoming from Brill in 2016.

In addition to her book awards, Crone's work has been acknowledged by many honors, including the Giorgio Levi Della Vida Medal for Excellence in Islamic Studies (2013) and the Middle East Medievalists Lifetime Achievement Award (2013), which recognizes scholars who have served the field of medieval Middle Eastern Studies with distinction. She was made an honorary Member of Gonville and Caius College at the University of Cambridge (2013) and received honorary doctorates from the University of Copenhagen (2009), Leiden University (2013), and The Hebrew University of Jerusalem (2014). She was a member of the American Philosophical Society and Corresponding Fellow of the British Academy, as well as founder and editor of the book series *Makers of the Muslim World*, which highlights scholars, artists, politicians, and religious leaders who made the Muslim world what it is today.

Crone is survived by her siblings Camilla Castenskiold, Clarissa Crone, Diana Crone Frank, and Alexander Crone. The documentary *For the Life of Me: Between Science and the Law,* created by Diana Crone Frank, depicts Crone's diagnosis of cancer and follows her quest to research and employ marijuana's potential cancer-fighting properties and to contextualize its longstanding legal prohibition. More details about the film may be found at www.forthelifeofmefilm.com.

There will be an event at the Institute this fall to celebrate Crone's life and work, and details will be shared in the near future.—*Christine Ferrara, Director of Communications, cferrara@ias.edu, and Alexandra Altman, Communications Associate, aaltman@ias.edu*

A Colloquium in Honor of Patricia Crone

On February 25, a one-day colloquium was organized by Sabine Schmidtke to honor Patricia Crone and her contributions to the study of Islam and Iran.

Talks were given by Hassan Ansari, Member in the School of Historical Studies, Michael Cook of Princeton University, Everett Rowson of New York University, Daniel Sheffield of Princeton University, Sarah Stroumsa of The Hebrew University of Jerusalem, and Kevin van Bladel of the Ohio State University. The speakers examined topics including Crone's contributions to the field of Islamic Studies; the reliability of sources on Muhammad's statecraft; the historicity of the mid-ninth-century Cordovan Voluntary Martyrs; Crone's contributions to premodern Iranian studies across the areas of politics, society, and religion; new insights into theories of the Persian origins of the Arab colonies Marw and Transoxania; and how a sixteenth-century astrologer and his followers' notions of millennialism and cosmology, theurgical practices, and code of conduct influenced a movement popularly portrayed as a forerunner of Indian secularism.

"The contributions that Patricia Crone has made to the study of early Islamic history can hardly be overstated," Petra Sijpesteijn, Professor of Arabic Language and Culture at Leiden University, noted. "Patricia stands fully in the finest Orientalist tradition of philological exactitude and sheer, exhaustive learning. . . . She has taken Islam, in other words, out of the peninsula and into the wider world of Late Antiquity, where it has remained ever since."


DAN KOMODA

Patricia Crone (right) with Sabine Schmidtke (center) at the colloquium in February

HASLAM *(Continued from page 1)*

as a leading authority in the study of the Soviet Union from 1930 to the end of the Cold War, and he remains a powerful voice in the field.

"The School of Historical Studies is delighted to have as a member of its Faculty a scholar with such a breadth of research interests in the field of international relations, which range from Latin America and the Soviet Union to the history of theoretical concepts," stated Angelos Chaniotis, Professor in the School of Historical Studies. "I am sure that the Members will profit enormously from the expertise of Jonathan Haslam. Professor Haslam's interests in the influence of ideas and ideologies on international relations, and in the factors that shaped the Cold War, build a bridge between historical studies and the understanding of contemporary phenomena."

Robbert Dijkgraaf, Director of the Institute and Leon Levy Professor, added, "We are very pleased to welcome to the Faculty of the Institute Jonathan Haslam, an outstanding scholar who brings an impressive range of study with potential for new engagement and dialogue across the Institute community."

"I attended the Institute very profitably as a Member two decades ago. Certainly I never dreamed of ever taking up the Kennan Chair, and in such distinguished company," said Haslam. "Coming in from a great university system now falling on hard times, vulnerable to demands from government that it must justify its existence purely in terms of utility, I cannot over-emphasize how important is the disinterested pursuit of knowledge for its own sake. The IAS epitomizes it as a result of Abraham Flexner's enlightened vision. Long may it prosper."

Haslam is the author of eight monographs, six collected volumes, and more than fifty articles. His first four books—*Soviet Foreign Policy, 1930–1933: The Impact of the Depression* (1983), *The Soviet Union and the Struggle for Collective Security in Europe, 1933–1939* (1984), *The Soviet Union and the Politics of Nuclear Weapons in Europe, 1969–1987* (1990), and *The Soviet Union and the Threat from the East, 1933–1941* (1992)—offer intensive explorations and interpretations of Soviet international relations and foreign policy in the context of economic, military, and political developments in Europe, Asia, and North America.

While a Member in the School of Historical Studies in 1998, Haslam worked on one of his most notable books, *The Vices of Integrity: E. H. Carr, 1892–1982* (1999), which explores the life and work of one of the twentieth century's most influential historians of the Soviet Union. Chronicling the influence of ideology on Carr's historical thinking and perception of the Soviet Union, the book is a major contribution to the historiography of international relations. With the volume *No Virtue Like Necessity: Realist Thought in International Relations since Machiavelli* (2002), Haslam created a model for contemporary international relations theory, showing the importance of tracing the underlying premises of realist thought to their origins.

Haslam's *Russia's Cold War: From the October Revolution to the Fall of the Wall* (2011) is the first comprehensive history of the Soviet Union's role in the Cold War, and is based on his research on hitherto unexploited archival material in various languages. One of Haslam's most original contributions is his study of Soviet intelligence operations, a subject to which he has also dedicated his next book: *Near and Distant Neighbors: A New History of Soviet Intelligence* (2015). Haslam has reinvigorated discussion on Soviet foreign policy with his bold views on how Soviet ideas of predominance in Europe sparked the Cold War, how ideology still influenced Soviet policy in the late 1960s, and the factors that led to the Soviet invasion of Afghanistan. His work has helped to create a well-rounded picture of the Soviet point of view and provides for a more balanced assessment of Soviet policies.

Apart from his work on the Soviet Union, Haslam has also studied American foreign policy in Latin America. In *The Nixon Administration and the Death of Allende's Chile: A Case of Assisted Suicide* (2005), Haslam conducted extensive archival research to investigate the role of U.S. policy under Richard Nixon in undermining Salvadore Allende's government, while simultaneously examining the faults of Allende's policies that ultimately resulted in the dictatorship in Chile.

Beyond his scholarly work, Haslam served as Member and Chairman of an international committee advising the Historical-Diplomatic Department of the Russian Foreign Ministry from 1992–96. He was also Special Adviser to the European Union Committee of the House of Lords, Sub-Committee for Common Security and Foreign Policy.

Haslam earned a B.Sc. (Econ.) in International Relations from the London School of Economics in 1972; an M. Litt. in the History of International Relations from Trinity College, Cambridge, in 1978; and a Ph.D. from the University of Birmingham in 1984. From 1988–91, Haslam was Senior Research Fellow in Politics at Kings College, Cambridge, and then served as Assistant Director of Studies in International Relations (Russia and Eastern Europe) at the University of Cambridge from 1991–2000. He was then a Reader in the History of International Relations until 2004, at which point he was named Professor of the History of International Relations. Haslam has also held academic positions and visiting professorships at several institutions, including Birmingham University; the University of California, Berkeley; Harvard University; Johns Hopkins University; Stanford University; and Yale University. He is a member of the editorial board of the *Annals of Communism* series of Yale University Press. Haslam is a Fellow of the British Academy; Corpus Christi College, Cambridge; and the Royal Historical Society and is a Member of the Society of Scholars at Johns Hopkins University.

—Christine Ferrara, Director of Communications, cferrara@ias.edu, and Alexandra Altman, Communications Associate, aaltman@ias.edu

New Trustee Appointments

The Institute for Advanced Study has appointed Afsaneh Mashayekhi Beschloss, Jonathan M. Nelson, and Sandra E. Peterson to its Board of Trustees, effective May 1, 2015.

PHOTO COURTESY OF THE ROCK CREEK GROUP

Afsaneh M. Beschloss

Afsaneh M. Beschloss is Founder and Chief Executive Officer of The Rock Creek Group, a global investment and advisory firm. Previously, she was Managing Director and Partner at the Carlyle Group. Prior to that, Beschloss was Treasurer and Chief Investment Officer of the World Bank, where she advised finance ministries and central banks on pension reform and financial policy.

Beschloss is currently a Director of the Public Broadcasting Service (PBS); the American Red Cross; the Urban Institute, where she chairs the Investment Committee; the World Resources Institute, where she co-chairs the Global Advisory Council; and the Visiting Committee for the Center for Development Economics at Williams College. She has served as Trustee of the Ford Foundation, where she chaired the Investment Committee, and the Colonial Williamsburg Foundation. She has received the Robert F. Kennedy Ripple of Hope Award, was recognized as one of American Bankers' Most Powerful Women in Banking, and was the recipient of the 100 Women in Hedge Fund Leadership Award. Beschloss is the co-author of *The Economics of Natural Gas* (Oxford University Press, 1990) and author of numerous journal articles on energy policy. She holds an M.Phil. (Honors) in Economics from the University of Oxford, where she taught international trade and economic development.

PHOTO COURTESY OF PROVIDENCE EQUITY PARTNERS

Jonathan M. Nelson

Jonathan M. Nelson is Founder and Chief Executive Officer of Providence Equity Partners, a private equity and credit investment firm. Nelson is currently a Director of the The Chernin Group, MLS Media, Television Broadcasts Limited, and Univision Communications. He has also served as a Director of numerous other Providence portfolio companies, including Eircom, Hulu, Language Line, MetroNet (now AT&T Canada), VoiceStream Wireless (now Deutsche Telekom), Warner Music Group, Western Wireless (now Alltel Corp.), and Yankees Entertainment and Sports Network.

Prior to founding Providence Equity Partners in 1989, Nelson was Managing Director of Narragansett Capital, which he joined in 1983, specializing in private equity investments in the cable television, broadcasting, and publishing sectors. Nelson is also a Trustee of Brown University and The Rockefeller University. He is a member of the Board of Dean's Advisors at Harvard Business School and serves on the Board of the Newport Festivals Foundation. Nelson received a Master of Business Administration from Harvard Business School and a Bachelor of Arts from Brown University.

PHOTO COURTESY OF JOHNSON & JOHNSON

Sandra E. Peterson

Sandra E. Peterson is Group Worldwide Chairman of Johnson & Johnson and a member of the Johnson & Johnson Executive Committee. She is responsible for both enterprise capabilities and consumer-facing businesses, overseeing the Consumer Group of Companies; consumer-directed medical device businesses Johnson & Johnson Vision Care and Johnson & Johnson Diabetes Solutions; and enterprise functions Johnson & Johnson Supply Chain, Information Technology, Health & Wellness, and Global Strategic Design.

Before joining Johnson & Johnson in 2012, Peterson was Chairman and Chief Executive Officer of Bayer CropScience AG in Germany. She also served at Bayer as President and Chief Executive Officer of Bayer Medical Care and President of Bayer HealthCare AG's Diabetes Care Division. Peterson has also held positions at Medco Health Solutions; Nabisco, Inc.; Whirlpool Corporation; and McKinsey & Company, Inc. She is a member of the Board of Directors of the Dun & Bradstreet Corporation. Peterson holds a Bachelor of Arts in Government from Cornell University and a Master of Public Administration in Applied Economics from Princeton University. ■

DANIEL S. FREED
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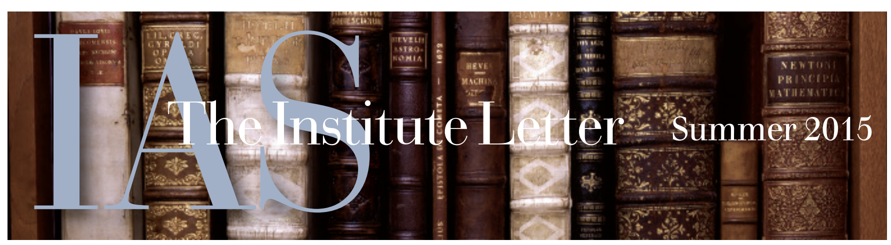

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