CCNY PHYSICS

The CCNY Physics Department Newsletter

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Features

Danny Greenberger and the 2022 Nobel Prize

The Inaugural Harry Lustig Lecture

CCNY physics

The City College of New York

Welcome to the 2022 CCNY Physics Department Newsletter.

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PHYSICS DEPARTMENT READING ROOM

Last January, a campus shuttle was borrowed to take a drive up to the former home of CCNY Physicist Alexander Marcus. The mission? Retrieve a recently donated library of books to add to our departmental reading room. The reading room will house a collection of the working libraries from several of our former faculty members.

Dr. Hedberg in Connecticut with the Alexander Marcus Library loaded in the Shuttle.

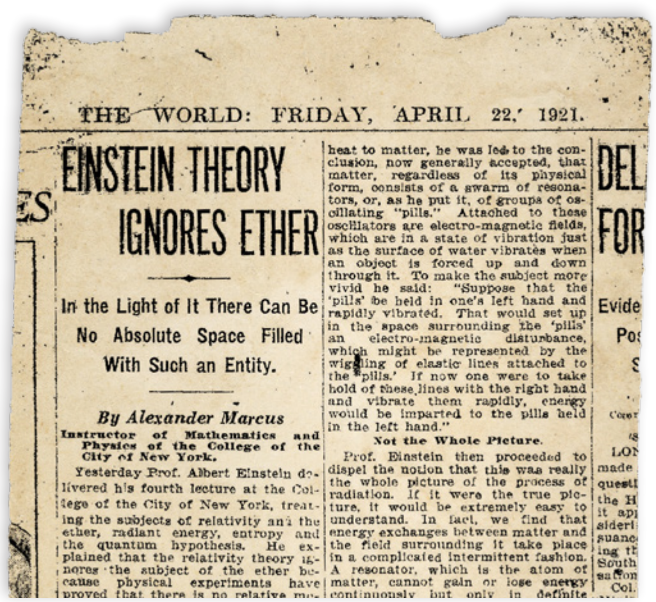
An earlier incarnation of the reading room was dedicated after the passing of Distinguished Professor Joseph Birman. The Birman-Cummins Reading Room was located on the third floor, and was used for some seminars and other events. But, the room was small and far off the beaten path to be used frequently. The new room will be located adjacent to our colloquium room, on the fourth floor of Marshak.

It will include selected working libraries of the department's faculty from various eras. A very exciting collection being prepared for display will be the library of Alexander Marcus, who was a faculty member in the department between the years of 1914-1958. The collection was donated by the Marcus Family in 2022. Professor Marcus was present during Albert Einstein's famous lectures on relativity and other related topics in physics delivered to the CCNY campus in 1921 and helped communicate these lectures to the public through several articles. His library features many historic volumes from the period in physics history when the world was just getting used to a new and unfamiliar landscape of physical reality demanded by the relativity theories.

Look for an exciting opening event this fall!

Left: A shelf filled with the Alexander Marcus Collection

Below: A clipping from the World April 22, 1921 issue reporting on the Einstein Lectures at City College.



THE WORLD: FRIDAY, APRIL 22, 1921.

EINSTEIN THEORY IGNORES ETHER

In the Light of It There Can Be No Absolute Space Filled With Such an Entity.

By Alexander Marcus

Instructor of Mathematics and Physics of the College of the City of New York.

Yesterday Prof. Albert Einstein delivered his fourth lecture at the College of the City of New York, treating the subjects of relativity and the ether, radiant energy, entropy and the quantum hypothesis. He explained that the relativity theory ignores the subject of the ether because physical experiments have proved that there is no relative me-

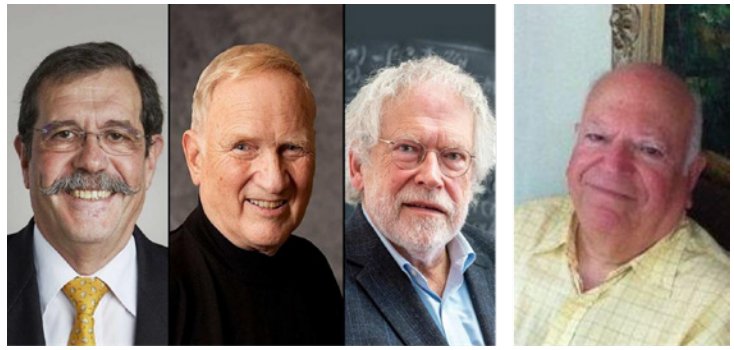
heat to matter, he was led to the conclusion, now generally accepted, that matter, regardless of its physical form, consists of a swarm of resonators, or, as he put it, of groups of oscillating "pills." Attached to these oscillators are electro-magnetic fields, which are in a state of vibration just as the surface of water vibrates when an object is forced up and down through it. To make the subject more vivid he said: "Suppose that the 'pills' be held in one's left hand and rapidly vibrated. That would set up in the space surrounding the 'pills' an electro-magnetic disturbance, which might be represented by the wiggling of elastic lines attached to the 'pills.' If now one were to take hold of these lines with the right hand and vibrate them rapidly, energy would be imparted to the pills held in the left hand."

Not the Whole Picture.

Prof. Einstein then proceeded to dispel the notion that this was really the whole picture of the process of radiation. If it were the true picture, it would be extremely easy to understand. In fact, we find that energy exchanges between matter and the field surrounding it take place in a complicated intermittent fashion. A resonator, which is the atom of matter, cannot gain or lose energy continuously but only in definite

DANNY GREENBERGER AND THE 2022 PHYSICS NOBEL PRIZE

Alexios Polychronakos



Left to Right: Alain Aspect, John Clauser, Anton Zeilinger, and Daniel Greenberger

Our beloved colleague Danny Greenberger, now a Distinguished Professor Emeritus, has been a defining long-time presence in our department and College. We all know him as a physicist of great depth and intuition, but also as a cheerful companion and friend who will brighten our day with his jovial conversation and good-hearted laughter.

Danny's natural curiosity and imagination led him to study, among other topics, the peculiarities of quantum mechanics and the concepts of measurement and entanglement. Danny's intellectual trek in this field produced some fundamental insights into quantum theory, and recently brought him within the shadow of the latest Physics Nobel prize (he was narrowly missed by it). This is a story worth telling.

Quantum mechanics has many strange features, but none more counterintuitive than its theory of measurement and the damage it does to our concept of physical reality. According to quantum theory, the properties that determine the outcomes of measurements on a system are not fixed a priori but come to be only as a result of the measurement being performed. Figuratively, a (quantum) face-down card is neither Ace nor King but assumes one of these values only when we care to flip it and look at it. This goes against our concept of objective reality, the understanding that the world *is*, irrespective of our observing it. Collateral damage is also done to our ideas of determinism (only probabilities can be calculated, outcomes cannot in general be predicted with certainty), precision (some quantities cannot be simultaneously measured without disturbing each other), and hypotheticals (you cannot a posteriori ask, "had I measured something else, what would I have seen?").

This did not sit well with many physicists (including, originally, Schrödinger himself). Einstein, in particular, was philosophically opposed to probabilities being part of a fundamental theory. With his colleagues Boris Podolsky and Nathan Rosen they considered a situation of two perfectly correlated particles shot at opposite directions. In the famous and influential 1935 Einstein-Podolsky-Rosen (EPR) paper[1] they attempted to show that quantum mechanics cannot be a complete theory of nature because of the drastic changes in realism that it requires. But in the end, the exceptional success of quantum mechanics in any situation where it was applied showed, instead, that such drastic changes *do* need to be accepted. Still, the theoretical possibility (or hope?) remained that quantum mechanics is only an "effective" theory, partially describing the tip of the iceberg of a deeper, hidden classical reality inaccessible to us due to the limitations of the probes that we use. This became known as the "hidden variables theory".

Most physicists did not believe that a classical hidden variables theory could emulate quantum mechanics in all its intricacies. Yet nobody had eliminated the possibility, until John Bell took up the task. Initially trying to vindicate Einstein, he eventually realized that quantum mechanics is weirder than (and incompatible with) any classical theory. In his seminal 1964 paper[2] Bell proposed an experimental setup involving two spins (or photons) correlated in a quantum way ("entangled") and three possible measurements performed on each of them by two independent non-communicating observers. The results of these experiments are statistically correlated. Any classical theory, no matter its structure or details, would give statistics for these measurements that fall within a certain range, that is, satisfying what is now called the Bell inequality. And yet a specific entangled pair of spins would produce measurement results violating this inequality. Thus, Bell showed that there are quantum situations that cannot be described by *any* classical hidden variable theory, unless we are willing to accept gross violations of causality, or a cosmic conspiracy predetermining all outcomes so as to trick us into believing in quantum theory! Such assumptions are not just ridiculously unreasonable but also unfalsifiable, and thus unscientific, leaving quantum mechanics as the only scientific, predictive physical theory.

This made most physicists happy and allowed them to continue using quantum theory with a renewed faith in its relevance. Still, a determined few continued thinking about the EPR situation, trying to probe deeper into the quantum nature of Nature. Bell's theorem had opened the door to a direct confrontation between classical and quantum physics, and essentially settled the issue of hidden variables, but some questions remained. One issue was that Bell's setup of two spins involved *imperfect* correlations between the measurements; that is, the result of a measurement by one of the observers did not uniquely determine the result of any measurement by the other observer. By contrast, in the EPR setup the correlation was perfect: a measurement of the spin of one particle fully determined the fate of the measurement of the other. In fact, EPR's basic thesis was that "*if, without in any way disturbing a system, we can predict with certainty (with probability equal to unity) the value of a physical quantity, then there exists an element of physical reality corresponding to this physical quantity.*" That is, there is something inherent and independent of our measurement, a classical deterministic description.

That's where Danny entered the picture in full force. In collaboration with his long-time friend and colleague Anton Zeilinger, an experimental quantum physicist in Vienna, and also with Michael Horne and Abner Shimony, they tackled the question: is Bell's argument restricted to situations with imperfect correlations, or it may also apply to perfect correlations, similar to the EPR situation? In a seminal 1989 paper with Horne and Zeilinger, Danny demonstrated[3] that, indeed, a classical description may be impossible even in situations with perfect correlations. In their original paper they demonstrated this with a system involving four spins. This setup was refined in a subsequent 1990 paper[4] with Horne, Shimony, and Zeilinger, in a construction involving only three spins.

The 1990 paper was a tour de force, but also a classic case of "burying the lede": it contained a wealth of calculations on a comprehensive set of situations, but the simple state and corresponding argument that persuasively made the case of no classical description was buried as a special case somewhere in the middle of page 7 of a 13-page paper. Fortunately, David Mermin took up the task of popularizing it. Already interested in the subject and impressed with the work of Danny and collaborators, he wrote a follow-up 1990 paper[5] in which he distilled the basic result and presented it clearly and concisely, stressing its nontrivial and surprising nature. This essentially canonized what became known as the GHZ (Greenberger-Horne-Zeilinger) state as the most "on your face" demonstration of the fundamentally non-classical nature of quantum mechanics.

The simplicity and beauty of the GHZ state are quite compelling and it is irresistible to describe it in some detail. We will largely follow the presentation of Mermin but will turn the setup into a card game (to stress the stochastic nature of the situation!).

Consider a card dealer dealing a hand of two face-down cards to three independent players. Each player receives one black card and one red card, and if any card is flipped it is exposed to be either an Ace or a King. Players can choose one of their cards, flip it, and see if it is an Ace or King, but then the dealer will forfeit the other card. So, each player can only see one of the two cards in each game.

The game is played several times, and each time each player makes a choice of card (black or red), flips it, and registers the result. Players can compare their results and draw conclusions. After a very long run of games, they notice some regularities. First, the games are independent; that is, what happened in one game does not influence any of the following games. Further, the statistics of the cards in each game are identical; that is, the probability of any specific outcome is the same in each new deal. Interestingly, there is one perfect correlation between the results in each game: if two of the players chose to open a black card and the third one a red card, they will see an even overall number of Aces (either none or two), irrespective of who chose the red card or where the aces appeared.

So the players get to think: could we possibly deduce from this perfect correlation the result of another situation? After some thought, they come up with a conclusion: even if they have never done this yet, if they all flip the red card, they are *sure* to also see an even number of Aces! Their reasoning is simple and ironclad: call B1 and R1 the black and red cards of player 1, and similarly for players 2 and 3. Further, assign to the cards the numerical value -1 if they are Aces and +1 if they are Kings. Then the perfect correlation they observed can simply be stated as the set of relations

B1 B2 R3 = 1, B1 R2 B3 = 1, R1 B2 B3 = 1,

which express the even number of -1 values for the three possible choices of one red and two black cards.

Now, the players argue, we may not be allowed to look at our other card once we flip the card we chose, but it still had some definite value, -1 (Ace) or +1 (King). Since the three relations above always hold, we can multiply them to find

R1 R2 R3 = 1

since B1 B1 = B2 B2 = B3 B3 = 1 no matter what their (+1 or -1) values are. Aha! So, if we all choose to flip red cards, we will also see an even number of Aces.

Excitedly, the players choose three red cards, flip them, and to their astonishment they see that the number of Aces is odd, and this happens every single time they do it. So R1 R2 R3 = -1, in flagrant contradiction to their previous result!

There are a couple of possible ways out: perhaps, when a player chooses a card, a signal is somehow sent to the cards of the other players, which with some hidden mechanism change value (from Ace to King or vice versa) so as to reproduce the above results. That is, the cards of one player depend on what cards the other players chose, a weird action-at-a-distance between the cards. The players can eliminate this by, say, moving to three different distant planets while playing the game (cards are sent to them via emissaries of the dealer in spaceships) such that their choices cannot be causally correlated.

Another possibility if that the dealer, by looking into their eyes can read their minds and know which cards they will choose to flip before dealing the cards, surreptitiously changing the value of the dealt cards so as to reproduce the above results, in a sly casino conspiracy. The players can eliminate this by resolving not to decide which card to flip before they are dealt the cards, or, better, by throwing a dice after they are dealt the cards to make their decisions random. Unless the dealer can influence their minds and the result of the dice, in a true cosmic conspiracy, this possibility is also eliminated.

So the players conclude that no system of dealing cards can produce this result. And yet they observe it! The one assumption that remains and needs to be modified is that the cards that they did not observe and were forfeited by the dealer had a definite value irrespective of the fact that they were not flipped. This is the assumption of reality that Einstein held so dear and thought that quantum mechanics was crazy for violating it. And yet, Nature chose to be quantum mechanical and to violate it. Sorry, Professor Einstein!

OK, let's now spill the beans (or flip the cards) and see what is behind this game. Each pair of cards is actually a single quantum mechanical spin. We "flip the black card" if we decide to measure it in the y direction and "flip the red card" if we decide to measure it in the x direction. If the result of the measurement is $+\hbar/2$ the card is a "King", and if it is $-\hbar/2$ it is an "Ace." So, with our assignment of values for the cards, R = σ_x and B = σ_y for each spin. Once we perform one of the measurements the state of the spin changes, so we "forfeit" the possibility to perform the alternative measurement on the same state. The three spins are produced jointly (by a "dealer") in a correlated state and sent to the three players. Their (unnormalized) entangled state is

$$|\Psi\rangle = |\uparrow\uparrow\uparrow\rangle - |\downarrow\downarrow\downarrow\rangle$$

with $\uparrow$ representing a spin-up and $\downarrow$ a spin-down in the z direction. Remembering that the action of σ_x is to flip the spin, and that of σ_y is to flip and multiply it by $+i$ (for $\uparrow$) or by $-i$ (for $\downarrow$) we can see that this state is an eigenstate of the operators

$$B1\ B2\ R3 = \sigma_{y,1}\ \sigma_{y,2}\ \sigma_{x,3}\ ,\ B1\ R2\ B3 = \sigma_{y,1}\ \sigma_{x,2}\ \sigma_{y,3}\ ,\ R1\ B2\ B3 = \sigma_{x,1}\ \sigma_{y,2}\ \sigma_{y,3}$$

with common eigenvalue +1. And we can see equally well that it is an eigenstate of the operator

$$R1\ R2\ R3 = \sigma_{x,1}\ \sigma_{x,2}\ \sigma_{x,3}$$

with an eigenvalue -1, fully reproducing the observed results. The "trick" in quantum mechanics is that when we multiply the first three operators to produce the last one, as in the case of classical cards, all operators again square to 1, but σ_x and σ_y for the same spin *anticommute*. Exactly one σ_y has to slide past a single σ_x to meet its counterpart, producing one additional minus sign. So, this quantum three-spin system has perfect correlations and violates classical physics, and in a rather dramatic way. Voilà!

The fact that it is enough to check a single RRR case in the GHZ state to eliminate a classical description has led to the oft-stated misconception that the GHZ state demonstrates the non-classical nature of Nature with a single measurement. This is, of course, not correct. We need to perform a large number of measurements to establish the three perfect correlations BBR = BRB = RBB = 1 with adequate certainty. Once these are established, then, indeed, a single measurement of a new kind (RRR) will suffice to show a contradiction with classical physics. The GHZ state is unique and intriguing not because it eliminates the need for statistics, but because it involves perfect correlations and yields a sharp, striking result.

The 2022 Physics Nobel Prize was awarded to experimentalists Alain Aspect, John Clauser, and Anton Zeilinger, "for experiments with entangled photons, establishing the violation of Bell inequalities and pioneering quantum information science". Danny and others who worked on the theory side did not share in the prize. Nevertheless, the technical background paper accompanying the press release of the 2022 Nobel prize[6] made an explicit mention to Danny, Horne, and Shimony, and gave a brief description of their GHZ state and its defying any classical description. (It also, initially, repeated the misconception about doing it with a single measurement, and subsequently corrected it – not even the members of the Nobel committee are infallible!).

Would John Bell, who passed on October 1, 1990, have received the Nobel prize at some point had he lived longer? Could Danny have shared in the prize, had things worked out a bit differently? We will never know; the answers being hidden forever in the realm of hypotheticals that neither quantum mechanics nor life itself allows us to answer. But perhaps this is not so important. Prizes and other formal recognitions are human constructs to motivate and validate our collective effort to understand Nature. Danny's simple and beautiful result will be with us forever, testament to a truth that we should never forget: Nature will always prove to be more interesting than we can ever imagine, and will regale us with wonderful surprises and insights. We should only care to look.

References

[1] Albert Einstein, Boris Podolsky, Nathan Rosen, "Can a Quantum-Mechanical Description of Physical Reality Be Considered Complete?" Physical Review **47**, 777-780 (1935).
[2] John S. Bell, "On the Einstein Podolsky Rosen Paradox" Physics **1**, 195-200 (1964).
[3] Daniel M. Greenberger, Michael A. Horne, A. Zeilinger, "Going Beyond Bell's Theorem" In: Kafatos, M. (ed) "Bell's Theorem, Quantum Theory and Conceptions of the Universe" Fundamental Theories of Physics, vol 37. Springer, Dordrecht; https://doi.org/10.1007/978-94-017-0849-4_10
[4] Daniel M. Greenberger, Michael A. Horne, Abner Shimony, Anton Zeilinger, "Bell's theorem without inequalities," American Journal of Physics **58**, 1131 (1990); doi: 10.1119/1.16243
[5] N. David Mermin, "Quantum mysteries revisited" American Journal of Physics **58**, 731 (1990); doi: 10.1119/1.16503
[6] https://www.nobelprize.org/uploads/2022/10/advanced-physicsprize2022-2.pdf

PHYSICS CLUB NEWS

The Physics Club of CCNY hosted a number of events in the fall 2022 semester. The first event was the "*Boba* Tea Event" in which members of the Physics Club, new and old, had a chance to come together and socialize while sipping iced *Boba* tea made by the members in the clubroom.

Next event was a talk titled "The Society of Physics Students, Be a Shark! Career Talk" delivered by Professor Matthew Wright from Adelphi University. Professor Wright told us about the different careers a physics major could possibly pursue. He presented data on the distribution of physics majors choosing careers in private and public sectors. He presented valuable information on how to network for jobs, such as in physics conferences.

The "CCNY Meets Climate Scientists" event in collaboration with Princeton University, and the "Fall 2022 Outreach Event" with Hamilton Grange Middle School were organized with the help of a past member and longtime friend of the club, Dr. Veeshan Narinesingh. Veeshan received his BS and PhD degrees in Physics from CCNY. He is now engaged in research on weather modeling at Princeton University. Graduate students from Princeton gave talks in the event on their research. Topics included exploration into how salt can accumulate in the atmosphere and considerations in modeling the atmosphere, their journey and paths from being an undergraduate to where they are now, followed by some great resources about career paths for Earth and Atmospheric Science majors.

The Outreach Event, a tradition of the Physics Club, used to be held almost every semester before the pandemic. We worked with Hamilton Grange Middle School to bring the tradition back in the fall 2022 semester. The event consisted of a variety of demonstrations displaying physical phenomena involving waves, electromagnetism, kinematics, superconductivity, and atmosphere dynamics. Many of the middle school students were amazed by the superconductivity demonstration which had a magnetic train track and had a magnetic train car which was supercooled with liquid nitrogen. The curiosity and amazement seen on the faces of the students is what inspires the future generations of young scientists, which the Physics Club intends to pursue more vigorously.

(Reported by Christopher Shen, Leon Orlov-Sullivan and Charanjot Singh)

Physics Club members with climate scientists from Princeton University.

Middle school students observing demonstrations organized by the CCNY Physics club members.

NEW FACULTY MEMBER

Dr. Johannes Flick joined the CCNY Physics Department as an Assistant Professor in August 2022. He obtained his Diploma in Physics from Karlsruhe Institute of Technology (KIT) in Karlsruhe, Germany in 2011. He then received his Ph.D. in theoretical Physics from the Fritz Haber Institute and Humboldt University of Berlin both in Berlin, Germany. After his Ph.D., Dr. Flick held a Postdoctoral Researcher position at the Max Planck Institute for the Structure and Dynamics of Matter, Hamburg, Germany (2016-2017) and a Postdoctoral Fellow at Harvard University, Cambridge, MA (2017-2019) funded by the DFG Research Fellowship. Prior to joining CCNY, he held a faculty position as Associate Research Scientist and Project Leader at the Center for Computational Quantum Physics (CCQ) of the Flatiron Institute in New York, NY, USA. Since August 2022, Dr. Flick holds a joint appointment as an Assistant Professor at CCNY and as an Affiliate Associate Research Scientist and Project Leader at the Center for Computational Quantum Physics of the Flatiron Institute.

Professor Flicks' research in Theoretical and Computational Condensed Matter and Chemical Physics is focused on a diverse class of problems addressing quantum systems: (a) Studying light-matter interactions on a microscopic level in particular in the strong-coupling regime. He is interested in both the development of new computational methods to describe these regimes, *e.g.* quantum-electrodynamical density-functional theory, as well as their applications in catalysis, spectroscopy, and quantum-information processing. (b) Investigations of quantum emitters in wide-bandgap materials. He is investigating these systems using electronic structure methods to describe the optical and electronic properties, Jahn Teller effects, or excitonic excitations in systems ranging from solid state materials such as diamond to two-dimensional materials such as hexagonal boron nitride (hBN) and transition metal dichalcogenides (TMDs). (c) His research group is investigating how to best utilize new emerging computational methods and platforms for electronic structure problems. For noisy-intermediate-scale quantum (NISQ) computers, they develop new hybrid quantum-classical algorithm and schemes that map logical and physical qubits most efficiently. Using machine-learning they explore the mappings of the Hohenberg-Kohn theorem to derive new exchange-correlation functionals that simplify the calculations.

INAUGURAL HARRY LUSTIG LECTURE

Ngee-Pong Chang

The inaugural Harry Lustig Lecture entitled, "Can AI be the Next Picasso" was delivered on Wednesday, April 27, 2022 by Arthur I. Miller, Emeritus Professor of History and Philosophy of Science at the University College London (UCL). The venue was the Advanced Science Research Center (ASRC) Auditorium on the south campus of the City College of New York (CCNY). Professor Brian Schwartz, Vice-President of Research at the Graduate Center of CUNY and a classmate of the speaker at CCNY, was the MC for the lecture


Arthur I. Miller

The Harry Lustig Lecture is planned to be given on scientific topics of general interest to attract audience across all STEM disciplines and beyond. This inaugural lecture succeeded in drawing audience from diverse backgrounds. In his talk Professor Miller focused on the exciting art, literature and music already being created by artificial neural networks and considered the key issue of whether machines can be creative like humans.

He presented evidence that AIs (Artificial Intelligence) are already creating works that we recognize as art, and then raised the question, but does this make them truly artists? Can AIs possess the attributes of living beings even though they are alien life forms? If and when this is the case, their intelligence will no longer be 'artificial' but as real as ours. The lecture was based on his acclaimed book *The Artist in the Machine: The World of AI-Powered Creativity*. The talk can be accessed on YouTube at: https://youtu.be/-I4l1u9Wq4k

Arthur Miller grew up in the Bronx, with an interest in art and music, and as he said on his website, he `became hooked on creativity. But in those days if you were smart, or thought you were, you studied physics.' So, he enrolled at CCNY and `studied physics with heavy doses of philosophy'. He went on to MIT for his Ph.D.in physics. After faculty positions at the University of Massachusetts and Harvard, he became Professor of History and Philosophy of Science at University College London in 1991. His interest in cognitive science led him to study the relation between art and science and between artistic and scientific creativity. He is the author of a ground-breaking theory of creativity which applies to both humans and machines. He has written many critically acclaimed books, including the Pulitzer Prize-nominated *Einstein, Picasso: Space, Time, and the Beauty that Causes Havoc*; *137: Jung, Pauli, and the Pursuit of a Scientific Obsession*.

The Lecture honors the legacy of Harry Lustig, a 1948 CCNY Physics graduate who after a Ph.D. at University of Illinois chose to return to CCNY as a young professor in 1953. In 1964 he was elected Department Chair, and since then progressively served as Dean of Science, and Vice-President for Academic Affairs and Provost of CCNY. He helped transform CCNY from a world-class teaching institution into a world-class research institution.

The transformation of CCNY began with Harry's successful 1965 NSF Center of Excellence Grant application that brought $1 Million to rejuvenate the department. He then made a personal trip to Rochester and persuaded Robert Marshak to return to CCNY as President. Marshak had studied at CCNY before being recruited to Columbia. The proceeds from the NSF grant enabled them to recruit world-class physicists, such as Bunji Sakita and Sam Lindenbaum in high-energy and particle physics as well as Mel Lax, Joe Birman, Herman Cummins, and Harry Swinney in condensed matter physics. After Marshak retired in 1979, Harry continued to build up CCNY in Science, Technology, Engineering and Math. In 1981, he was a leader in building a bridge to China and brought outstanding CUSPEA students to the graduate program at CCNY and CUNY. Harry retired from CCNY in 1993 and went on to be treasurer of American Physical Society and Acting Executive Secretary.

The Harry Lustig Lecture is supported by the Harry Lustig Fund, established in 2020 in honor of Harry Lustig. It is a dedicated fund, which would be used to award the Harry Lustig Prize ($1000) to the annual Division of Science Valedictorian, as well as for the Harry Lustig Lecture. Harry Lustig Lecture is to be an annual (or semi-annual) Lecture on promoting CCNY's interest & role in advancing the frontiers of Science, Technology, Engineering and Mathematics for the benefit of society at large. The lecturers need not be necessarily from CCNY but should be well-known communicators who can edify the public on timely topics and enhance the stature of CCNY. The lectures are not to be a technical colloquium but should be given at a popular level. The department has set up a special committee to screen and select a proper topic and speaker for the lecture.

Harry Lustig

We need your support and help in reaching this goal. To contribute to the fund, please visit the website for Foundation for City College at the link: https://www.ccny.cuny.edu/giving Click on **Designation**: Division of Science, and under **Comments**: add the name: Harry Lustig Fund so that the money will be deposited in the designated fund.

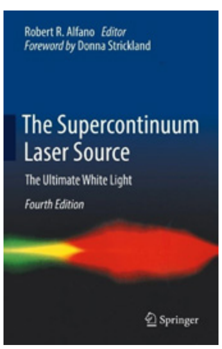
FACULTY ACHIEVEMENTS AND HONORS

Ronald Koder Promoted

Dr. Ronald Koder has recently been promoted to the rank of Professor. He received his BS and PhD degrees from the University of Missouri and the Johns Hopkins University, respectively. After a postdoctoral stint at the University of Pennsylvania (UPenn), he joined the CCNY Physics Department as an Assistant Professor in 2007. He became an Associate Professor in 2012 and was named the James L. Peace chair in Physics the same year.

Professor Koder's areas of research interest are: experimental biological physics, biodesign, synthetic biology, nuclear magnetic resonance, biosensors, and biohybrid metamaterials. His PhD thesis investigated the structure and mechanism of the prodrug-activating flavoenzyme nitroreductase. As a postdoctoral researcher at the UPenn School of medicine, he worked on the design and optimization of artificial oxygen transport proteins. Since joining the City College Professor Koder has focused his research on protein design projects in solar biofuels, enzymatic chemotherapies, and biological sensing. Ongoing research projects in Koder lab include: (a) Solar light-driven biofuel generation, (b) Development of methods for high signal-to-noise biosensing (detecting cancer biomarkers, biomarkers for COVID and car-T syndrome disease progression, chemical weapons, etc.); (c) Design of simplified but fully functional artificial elastin proteins aimed at understanding the structure and dynamics of elastin that makes up blood vessel walls and drives the elastic recoil necessary for cardiac function; and (d) Developing systems for in vivo photonic computation. These research projects are supported, in part, by grants from Air Force Office of Scientific Research (AFOSR), Congressionally Directed Medical Research Program (CDMRP), Defense Advanced Research Projects Agency (DARPA), National Science Foundation (NSF), National Institute for Health (NIH), and New York State Energy Research and Development Authority (NYSERDA).

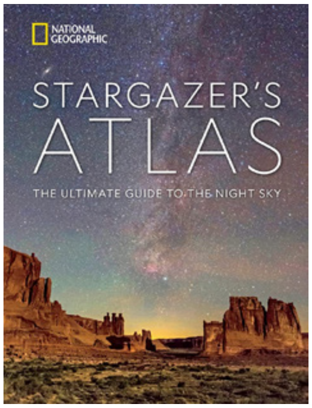
The Supercontinium Laser Source



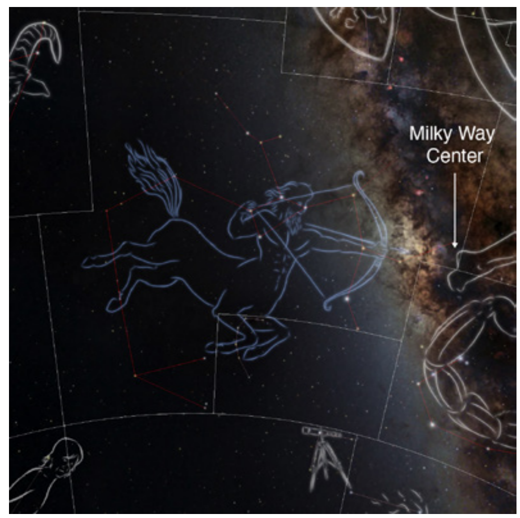
Springer recently published the Fourth Edition of *The Supercontinuum Laser Source* edited by Distinguished Professor Robert R. Alfano. Professor Alfano and Dr. Stanley Shapiro observed ultrafast broadband light generation in 1969 when they focused ultrashort pulses of light into transparent liquids and solids. With the advent of shorter pulses and sophisticated optical fibers as media the bandwidth of the generated broadband light continued to expand. Today even commercially available broadband lasers based on ultrafast supercontinuum generation cover the near-ultraviolet to mid-infrared wavelength range with wide applications in basic research, medicine, time and frequency metrology, optical communication and atmospheric science.

This fourth edition of the book reviews the linear and nonlinear processes responsible for supercontinuum generation. It begins with chapters that review the experimental methods and theoretical understanding of processes for generation of the supercontinuum. Subsequent chapters cover recent developments in supercontinuum generation, novel applications, and advances achieved since the publication of the previous edition. The new chapters focus on: filamentation in gases, air, and condensed media; conical emission by four-wave mixing and X-waves; electronic self-phase mechanism; higher harmonics generation; attosecond laser pulses; complex vector beam supercontinuum; higher order self-phase modulation and cross-phase modulation; nonlinear supercontinuum interference in uniaxial crystals; new nonlinear microscopes involving supercontinuum and ultrafast lasers with biomedical applications; and other current supercontinuum applications in communications. Donna Strickland, a 2018 Physics Nobel laureate provided a foreword for the book.

Hedberg Illustrates the Mythology of the Cosmos



Physics Lecturer and Planetarium Director James Hedberg created a set of drawings of the 88 IAU constellations for the recently published National Geographic *Stargazer's Atlas: The Ultimate Guide to the Night Sky*. The project started several years ago when he contributed a version of all 88 constellation figures for the open source Planetarium / Astrovizualization software OpenSpace, which is used by planetariums around the world. While the constellations themselves are not based on the astrophysics of the sky and don't inform our scientific understanding, they are an important part of astronomy, since they serve as a reference map of locations and regions in the night sky. The black hole at the center of our Milky Way galaxy for example, is referred to as Sgr A*, short for Sagittarius A*, as it can be found near the tip of the archer's arrow. Our nearest stellar neighbors, the stars in the system Alpha Centauri, are likewise located within the bounds of the constellation Centaurus. Additionally, the mythologies and cultural heritage they evoke in our globally shared night sky are fascinating. Different cultures had different interpretations about what they saw after the sun went down. The 88 official IAU constellations are just a small selection of the various figures and shapes seen by skywatchers over the millennia. The only aspect of the constellations rigidly set by the astronomy community are their boundaries, the rest is open to interpretation. Meaning, the figures themselves are not prescribed by any scientific agreements which allows for much artistic interpretation. However, tradition and star name etymologies help guide the decisions about say, where to put the arms of Orion or the waters of Aquarius.



The location of the black hole at the center of the Milky Way, as shown in OpenSpace.

STUDENT AWARDS

The Physics Department gives out several awards and scholarships to undergraduate students every year. The following students won the awards for the 2021-2022 Academic Year.

Sidney Millman Scholarship — Michael Rodriguez

presented to the junior Physics major demonstrating high potential

Sonkin Medal — Sorah Fischer

for the best performance in the Physics laboratory course(s) and/or in experimental research.

Ward Medal — Nipun Koshey

presented to the graduating physics major with the highest GPA in physics and mathematics courses

Bernard Hamermesh Scholarship — Shuva Roy

recognizes the outstanding graduating Physics major, who has demonstrated some of the skills, knowledge, technique and imagination necessary for a successful Experimental Physicist and who shows promise of being an active contributor to the research efforts in some branch of Experimental Physics.

Physics Department Student Support Scholarship — Abdullah M Khan, Michael Rodriguez

presented to a student who is majoring in Mathematics and Physics

Martin A. Tiersten Scholarship — Lyes Bensaadi

recognizes the students with the highest performance in Mechanics (Physics 35100)

Harry Soodak Scholarship — Luis Rodriguez

given to the outstanding junior physics major who wants to pursue a career in Physics

Michio Kaku Award — Polina Belousova

recognizes the outstanding graduating Physics major who has demonstrated some of the skills, knowledge, technique and imagination necessary for a successful Theoretical Physicist.

Zemansky Introductory Physics Prize

recognizes outstanding scholarship in Introductory Physics 20700 or Physics 20800 courses

Jeevan Bastola
Eden Chan
Choeden Dolma
Nitay Eshed
Nipun Koshy
Luis Rodriguez
Asem Sayed
Dawa Sherpa
Pamela Tabaquin

RECENT GRADUATES

Annual Commencement exercises are festive occasions in academic institutions that recognize and celebrate students' academic achievements culminating from years of dedicated work. What follows is a list of students who earned their BS, MS and PhD degrees recently.

BS Degree recipients

Fall 2021: Jefferson Almonte, Sorah Fischer*, Mohammed Islam, Natascha Krishnanand, Kevin Lei, Tyler Reese

Spring 2022: Johnny Basurto Rosales, Ian Brinkley, Tony Chan, Avraham Chen, Dahkota Debold*, Nicholas Drexler, Bryan Gonzalez, Sarah Medina, Shuva Roy*

(**Graduated with Research Honors*)

MS Degree recipients

Fall 2021: Paul Molinaro

Spring 2022: Ishan Darji, Yingie Huang, Levben Parsons, Dana Tritone, Jia Hui Weng

PhD Degree recipients

The following individuals received their PhD degrees from the joint Graduate Center of CUNY and the City College of New York Doctoral Program.

Mandeep Khatoniar, Thesis Title: *Linear and Nonlinear Properties of Two-Dimensional Exciton-Polaritons*. (Advisor: Vinod M. Menon), September 2021

Mengyao Li, Thesis Title: *Topological Classical Wave Systems with Modulations, Interactions, and Higher-Order Topological States*. (Advisor: Alexander B. Khanikaev), September 2021

Yingying Zhang, Thesis Title: *Monte Carlo, Molecular Dynamics and Network Analysis of The Gramicidin Water Channel and Proton Transfer Pathways to QB in Photosynthetic Reaction Centers*. (Advisor: Marilyn R. Gunner), September 2021

Damon S. Daw, Thesis Title: *Charge Transport and Spin Dynamics of Color Centers in Diamond*.
(Advisor: Carlos A. Meriles), February 2022

Veeshan T. Narinesingh, Thesis Title: *Connections Between Atmospheric Blocking, General Circulation, and Weather Extremes in a Hierarchy of Models and Various Climates.*
(Advisor: James F. Booth), February 2022

Ian Leifer, Thesis Title: *Symmetry-inspired Analysis of Biological Networks.*
(Advisor: Hernán A. Makse), June 2022

On the cover: Distinguished Professor Danny Greenberger.
Who knows what he's got up his sleeves?

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