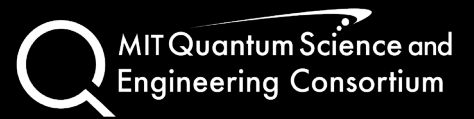
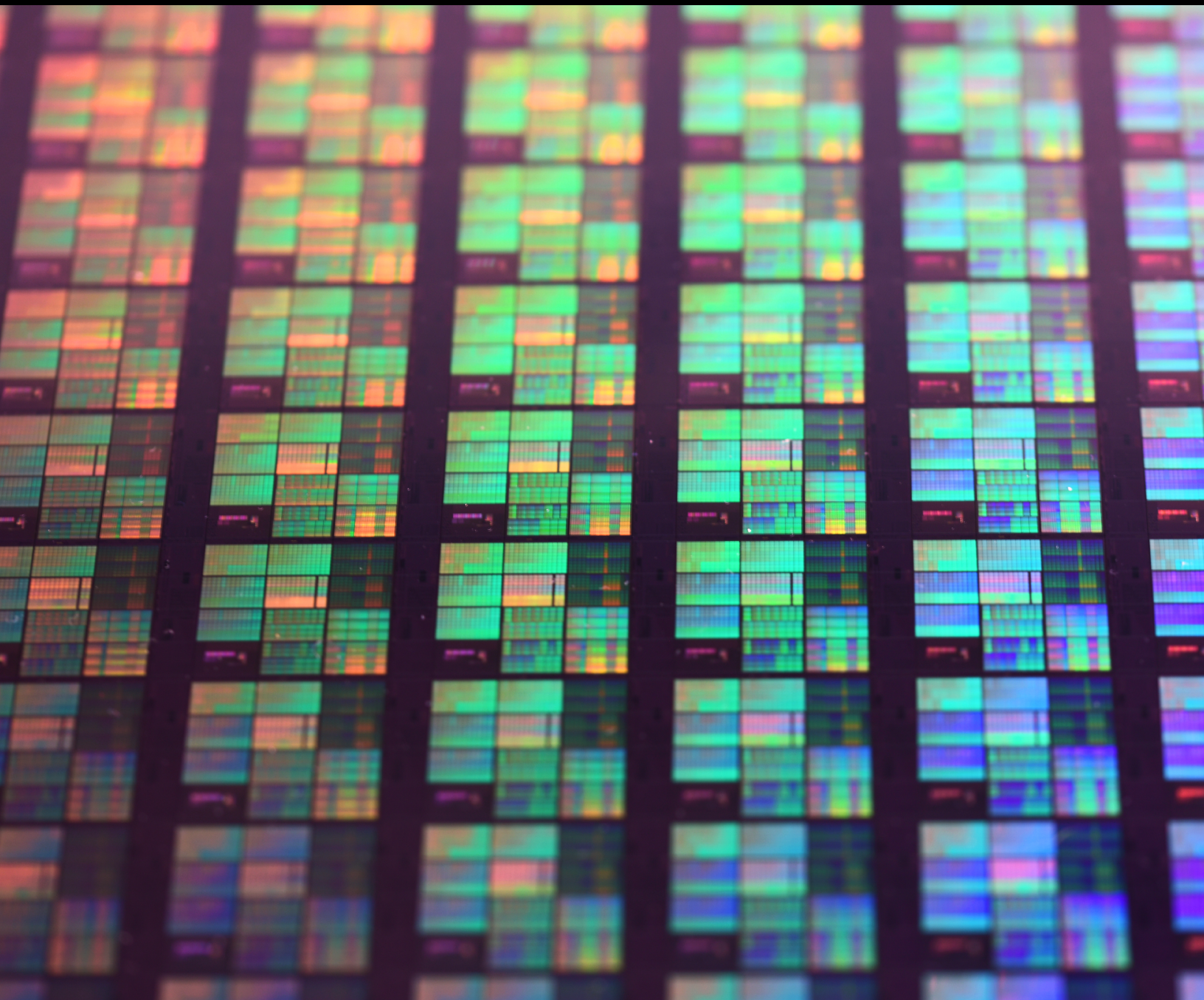


VOLUME 5



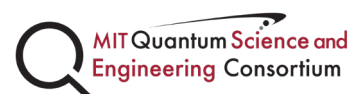
QSEC Newsletter



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MIT-CQE Mission

MIT's Center for Quantum Engineering is dedicated to the academic pursuit and practice of science and engineering to accelerate the practical application of quantum technologies for the betterment of humankind.

FROM THE DIRECTOR

It is our pleasure to present the final 2022 Quantum Science and Engineering Consortium (QSEC) newsletter.

Our QSEC membership group is growing! We extend a warm welcome to our new members: Chevron

Sustaining members: Dell Technologies, HSBC Global Services (UK) Limited, and Hyundai Motor Company.

In addition, we are pleased to welcome several faculty to the Center for Quantum Engineering:

- Dean, School of Science, Prof. Nergis Mavalvala, Physics
- Prof. Jonathan Ruane, Sloan School
- PI Neil Thompson, CSAIL
- Prof. Adam Willard, Chemistry

The fall term launched several membership activities. One is the continuing iQulSE-CQE weekly seminar series, which features leading researchers worldwide and is organized by MIT's iQulSE graduate student group. We also hosted our member recruiting "Deep Tech Career Fair" on October 4th.

QuARC 2023, the QSEC Annual Research Conference was held in January 2023 at the Omni Mount Washington Resort in New Hampshire. Please keep an eye out for the next newsletter highlighting the wonderful conference. Thank you to all who attended.



PROFESSOR

Henry Ellis Warren (1894) Professor of Electrical Engineering and Computer Science and of Physics

DIRECTOR

MIT Center for Quantum Engineering (CQE)

ASSOCIATE DIRECTOR

Research Laboratory of Electronics

LINCOLN LABORATORY FELLOW

William D. Oliver

william.oliver@mit.edu

CQE PI FEATURE

Freedman has been named a recipient of a 2022 MacArthur Fellowship

Asked once about the most difficult part of her research, Danna Freedman could not stop referring to obstacles as opportunities, and to challenges as excitement. “Every time we hit a barrier it enables us to discover new science,” she told an interviewer at Northwestern University in 2017, describing difficulties encountered in her research as among her most “rewarding” moments.

For Freedman, MIT’s F.G. Keyes Professor of Chemistry, focusing on a difficult problem seems to be her idea of nirvana. Currently, her research group is using inorganic chemistry to create molecules for quantum information science, generating a new class of quantum units that can be readily tuned for quantum communication. But at any given time, her idea of a favorite breakthrough is generally the challenge at hand.

“I love the most recent result, the thing I am struggling to understand and improve at a particular moment in time,” Freedman says.

Her determination and enthusiasm for the unsolved problem began as she was growing up in a small town in upstate New York, where early on she showed a strong interest in science and the questions scientists work to answer.

Freedman says her parents “patiently participated in hours of conversation



DANNA FREEDMAN

Frederick George Keyes Professor
of Chemistry

about the best way to drop an egg an arbitrary number of stories without breaking it.”

“Unfortunately, I hear bungee egg drop is no longer a Science Olympiad event,” she jokes.

Referring to her more recent endeavors, Freedman says her lab’s bottom-up design of molecules that can function as tunable, scalable, versatile, and robust qubits is an important step toward full realization of quantum sensing and communication. Such quantum operations could uncover new information about the world around us, sense dark matter, lead to insight in biological systems, or help transmit information across complex messy interfaces in a quantum state.

“We have developed a different approach to such a goal,” Freedman says. “It will take a long, dedicated,

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interdisciplinary effort to bring these ideas to fruition, and I am incredibly excited to make that happen.”

One of the ways Freedman and her lab are working collaboratively across disciplines is through the Q-NEXT National Quantum Information Science Research Center, which is led by the U.S. Department of Energy’s Argonne National Laboratory. With support from Q-NEXT and others, Freedman and members of her team as well as researchers from the University of Chicago and Columbia University recently published a paper in the *Journal of the American Chemical Society* demonstrating that a specific group of qubits — in this case molecules designed with a central chromium atom surrounded by four hydrocarbon molecules — could be customized for specific targets within quantum sensing and communication.

“As part of Q-NEXT and other research centers, we are incorporating these molecules into the larger quantum ecosystem,” says Freedman, whose work has garnered her many honors, including Presidential Early Career Awards for Scientists and Engineers through the U.S. Department of Defense and the National Science Foundation.

Freedman’s lab also works on applying extreme pressure, sometimes comparable to the pressures at the Earth’s core, to synthesize new materials. Her team is exploring one such material, the first iron-bismuth binary compound, for its magnetic properties and potential as a superconductor, both aspects that could

have broad ramifications in such areas as energy generation and transport.

Freedman’s characteristic ambition also shines through in her teaching and mentoring. She says that helping young researchers to develop involves “providing them with a foundation to excel and then throwing them into the deep end and asking them to swim.” But if they don’t succeed, she says, then “the foundation isn’t there, and I need to work harder, and try different approaches to prepare them.”

With her determination to seek new and expanding challenges, Freedman came to MIT in 2021, having moved from Northwestern University, where she was a professor of chemistry. She says the potential for collaboration at MIT enhanced her motivation.

“I am about 10 years into my career, and as our research expands in new directions, I wanted to form teams that extend beyond my own research and to connect in different directions,” Freedman says. “When I spoke with faculty at MIT, every idea that I had expanded and became more achievable. The visions of the scientists and engineers at MIT spur me to have better ideas and to be a better scientist.”

She says she is “invigorated by the culture of the Institute. I continue to be impressed with the kindness and dedication and equitable culture that I have observed here. It is incumbent upon me to continue to improve it, but it is a phenomenal starting point.”

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And from that starting point, proceeding despite obstacles is obvious. Her great forward momentum is perhaps also evidenced by her great love of walking and running, which she tries to do every day.

“In Boston, I have walked along most train lines,” she says, adding that she also enjoys running “from Harvard Square down North Harvard Street to Coolidge Corner, on to the Chestnut Hill Reservoir and back along Commonwealth. I like running from MIT to the Chestnut Hill Reservoir and back ... and in Belmont, running on the Minuteman trail.”

“While walking or running,” Freedman says, “I turn existing thoughts into coherent sentences, create talks and refine ideas.”

CQE STUDENT FEATURE

Quantum Engineering Group: Andrew Stasiuk

Research group name: Quantum Engineering Group

Research Advisor: Paola Cappellaro

Hometown, Country: Rockaway, NJ, USA

Academic History Prior to coming to MIT: B. Math Mathematical Physics, University of Waterloo

M. Math Applied Mathematics - Quantum Information, University of Waterloo

What brought you to MIT? During my Master's research, I quickly found that life as a theorist in quantum information, while rich and fulfilling, was not for me. By the end of that degree, I realized that I was sorely missing the experimental component of scientific exploration. I was fortunate to have great mentors, who suggested I reach out to Paola Cappellaro, my current advisor, as they believed our research methodologies would align well. One year into my time at MIT, I am happy to say that I was advised extremely well; there is no other research institution in the world I would rather be a part of.

What interests you most about your research? NMR is an old and well studied field. I often joke that all of the good papers were written in the '50s and '60s. What excites me about our solid state NMR quantum simu-



ANDREW STASIUK

CQE-LPS Doc Bedard Fellow. This three-year graduate fellowship is awarded through the MIT Center for Quantum Engineering. It is funded by the Laboratory of Physical Sciences and recognizes the achievements and technical leadership of Dr. Fernand (Doc) Bedard, a pioneer of cryogenic computing.

lator is that even though the fundamental techniques have been well known for decades, we are still able to discover new techniques and find novel ways to push the limits of our system. In fact, having such a rich history of publication is a huge boon to my work. Complex pulse sequences for Hamiltonian engineering have been an integral part of the field for decades; when I am faced with a quantum simulation problem, I can browse through a rich toolbox of well understood techniques in search for a solution. By combining and leveraging various combinations of individual tools, we are able to devise techniques to induce an ever expanding set of observables of interacting quantum systems.

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Within my first year of research, I've had the opportunity to explore operator thermalization through out-of-time-order correlators and emergent time crystallinity due to Floquet driving. Using established techniques, and introducing new ones when needed, we are able to be extremely agile in our experimental exploration of complex quantum systems. While our NMR system may not be a viable candidate for full scale quantum computation, we continue to demonstrate its versatility and viability for quantum simulation. I can't wait to see what we think up next.

What are your future plans? Before starting at MIT I had the opportunity to work for Quantum Benchmark, now Keysight, and experience what life was like in the "quantum private sector". Thanks to this experience, I am confident that after my PhD I would like to return to industry. Now, the quantum landscape is rapidly changing, with new companies and technologies launching each year. In four years time, who knows what opportunities will be available. In the meantime, my focus is on becoming the best research scientist I can be, to prepare for a fruitful future career in quantum.

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**MICHAEL
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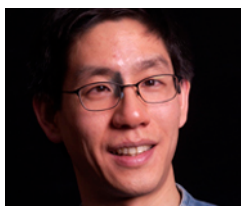
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**SOONWON
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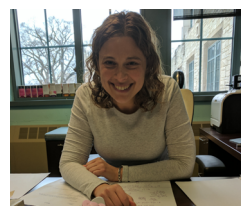
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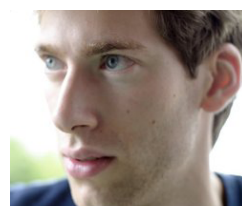
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HARROW**
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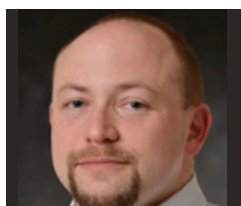
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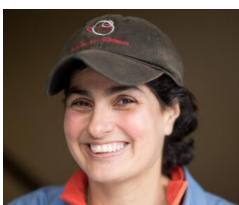
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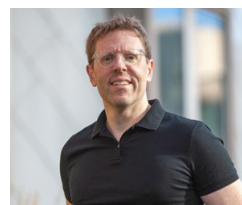
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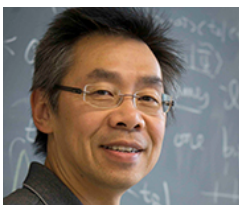
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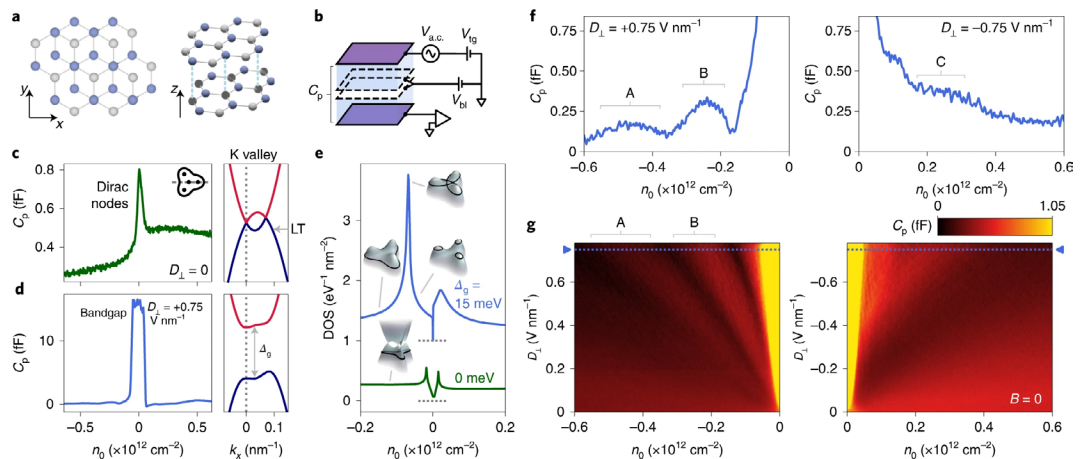
JONILYN YODER
Lincoln
Laboratory



**MARTIN
ZWIERLEIN**
Physics

“Cascade of isospin phase transitions in Bernal-stacked bilayer graphene at zero magnetic field”

Sergio C de la Barrera, Samuel Aronson, Zhiren Zheng, Kenji Watanabe, Takashi Taniguchi, Qiong Ma, Pablo Jarillo-Herrero, Raymond Ashoori
[Nature Physics volume 18, pages771–775 \(2022\)](#) | [arXiv:2110.13907 \(2021\)](#)

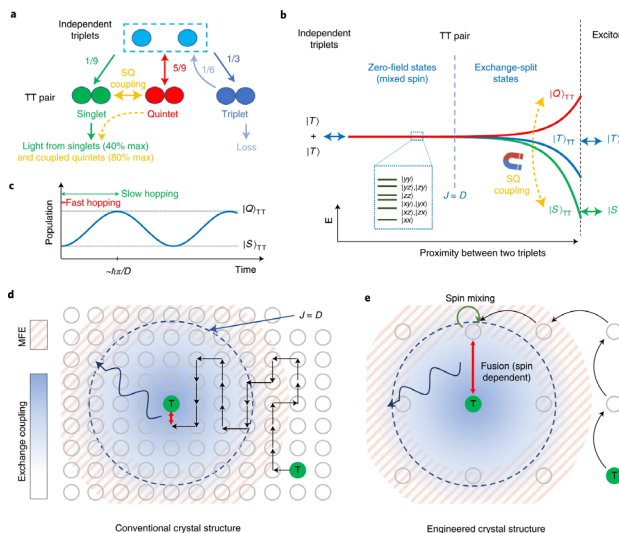
**Flat dispersion in Bernal-stacked bilayer graphene.**

a, Bernal-stacked (AB) bilayer graphene structure. b, Schematic of C_p measurement. Effective gate voltages are defined as $V_t = V_{tg} - V_{bl}$ and $V_b = -V_{bl}$, where V_{bl} is the d.c. voltage applied to the bilayer graphene. c, Measured C_p versus carrier density n_0 at zero electric displacement and $D_{\perp} = 0$ (left). Corresponding calculated, non-interacting band structure along the $K \rightarrow \Gamma$ direction showing two of the four Dirac nodes (right). Although only one valley is shown, the non-interacting bands are $4\times$ degenerate due to the combined spin and valley degrees of freedom. The inset shows the Fermi contour showing the effect of trigonal warping around K and relative position of the Dirac nodes (points). The dashed line indicates the k slice along which the bands are shown. d, Measured C_p at $D_{\perp} = 0.75 \text{ V nm}^{-1}$ showing an incompressible peak in the bandgap of the bilayer (left). Calculated, non-interacting band structure with emerging flat dispersion driven by the $D_{\perp}$ field (right). e, Calculated density of states (DOS) versus carrier density for two values of interlayer potential asymmetry, Δ_g , showing a single Van Hove singularity per conduction/valence band. The gap between the bands collapses to a single point ($n = 0$) when plotted versus density, rather than energy. The inset shows the band surfaces with isoenergy contours for different carrier densities (only the valence band is shown for $\Delta_g \neq 0$). f, Details of the trace from $D_{\perp} = 0.75 \text{ V nm}^{-1}$ (as shown in d) showing two prominent peaks on the hole side of the incompressible peak, labelled as A and B, with the corresponding trace from $D_{\perp} = -0.75 \text{ V nm}^{-1}$ showing shoulder features on the electron side of charge neutrality, with label C indicating a broad shoulder region where additional features emerge in finite magnetic field. g, Map of C_p measured as a function of n_0 and $D_{\perp}$ at 40 mK. Equivalent map for electrons with $D < 0$ (which is clearer than $D > 0$ for electrons; Supplementary Fig. 3 shows the full map) (right). Positions of the peaks in f depend linearly on the magnitude of $D_{\perp}$.

MARC BALDO, EECS

“Exchange controlled triplet fusion in metal–organic frameworks”

Dong-Gwang Ha, Ruomeng Wan, Changhae Andrew Kim, Ting-An Lin, Luming Yang, Troy Van Voorhis, Marc A Baldo, Mircea Dincă.

[Nature Materials \(2022\)](#)

a, Schematic illustration of TT pair dynamics. More than half of the TT pairs form quintet states initially, thus control of SQ coupling can substantially impact triplet fission and fusion efficiencies. b, Energy levels and spin states of nine eigenstates of TT pairs as a function of the distance between two triplet excitons. As shown in the inset, in a separated TT pair, the eigenstates are mixed SQ or triplet–quintet states governed by the zero-field splitting defined by the parameters D and E (ref. 50). The intertriplet exchange interaction, J , dominates as the triplets get closer, eventually yielding pure-spin eigenstates. c, A resonant magnetic field can drive an oscillation between the singlet and quintet states. For SQ splitting on the order of D , the spin transition time is $\sim \hbar\pi/D$. d,e, Spatial description of triplet fusion in molecular solids (d) and MOFs (e). Moderate applied magnetic fields $\mu B \approx D$ reshuffle the singlet, triplet and quintet character of TT pairs in the shaded magnetic field effect (MFE) regions,

generating both the conventional Merrifield MFE and potentially SQ resonances. TT states with weaker exchange splitting $J \approx D$ may be precursors to exciton formation in MOFs. In a typical densely packed molecular solid, however, triplets migrate rapidly relative to $\hbar\pi/D$ and fusion typically occurs from a triplet pair with exchange splitting $J \gg D$. This means that, in molecular solids, SQ resonances may only be observed under very high applied magnetic fields $\mu BB \gg D$ and low temperature, if at all.

KARL K. BERGGREN, EECS

“Self-heating hotspots in superconducting nanowires cooled by phonon black-body radiation”

Andrew Dane, Jason Allmaras, Di Zhu, Murat Onen, Marco Colangelo, Reza Baghdadi, Jean-Luc Tambasco, Yukimi Morimoto, Ignacio Estay Forno, Ilya Charaev, Qingyuan Zhao, Mikhail Skvortsov, Alexander Kozorezov & Karl K. Berggren.

[Nature Communications 13: 5429 \(2022\)](#) | [arXiv:2104.04652 \(2021\)](#)

● **Around the Institute**

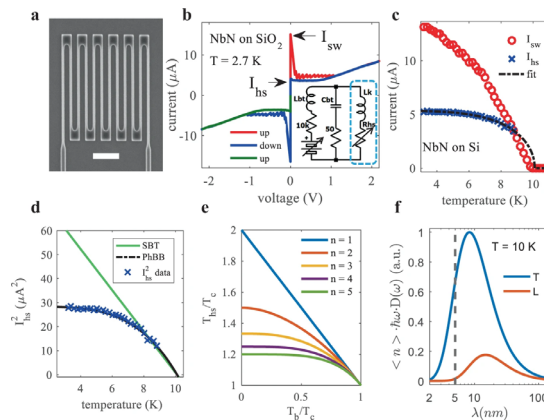
Beyond the Institute

Quantum Conferences



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KARL K. BERGGREN, EECS



10 K, using the Debye model for the phonon density of states. Both curves have been normalized by the maximum of the transverse curve. Typical film thickness (5 nm) indicated by dashed line.

a Scanning electron micrograph of a device measured for this work. Scale bar is 1 μm . b Typical hysteretic IV curve of a superconducting NbN nanowire with the switching (I_{sw}) and hotspot (I_{hs}) currents labeled. The measurement circuit is inset. Only the nanowire was cooled (blue dashed box). c $I_{sw}(T)$ and $I_{hs}(T)$ for NbN on Si device. Fitting of I_{hs} is shown and discussed below. d The $I_{hs}(T)$ data and fit from c was squared and re-plotted. Displayed this way, it is easy to see the failure of the linearized SBT model to capture the shape of the data. e Calculated hotspot temperature (T_{hs}) as a function of T/T_c and the exponent n which describes the power law cooling to the substrate. f Normalized energy density carried by three-dimensional longitudinal (orange) and transverse (blue) phonons in NbN as a function of wavelength at

“A superconducting nanowire-based architecture for neuromorphic computing”

Andres Lombo, Jesus Lares, Matteo Castellani, Chi-Ning Chou, Nancy Lynch, Karl K Berggren

[Neuromorphic Computing and Engineering \(2022\)](#) | [arXiv:2112.08928 \(2021\)](#)

“Single-photon detection using high-temperature superconductors”

I Charaev, DA Bandurin, AT Bollinger, IY Phinney, I Drozdov, M Colangelo, BA Butters, T Taniguchi, K Watanabe, X He, I Božović, P Jarillo-Herrero, KK Berggren

[arXiv:2208.05674 \(2022\)](#)

“Free-electron-light interactions in nanophotonics”

Charles Roques-Carmes, Steven E Kooi, Yi Yang, Nicholas Rivera, Phillip D Keathley, John D Joannopoulos, Steven G Johnson, Ido Kaminer, Karl K Berggren, Marin Soljačić

[arxiv.2208.02368 \(2022\)](#)

Large-Area Superconducting Nanowire Single-Photon Detectors for Operation at Wavelengths up to 7.4 μm

Marco Colangelo, Alexander B Walter, Boris A Korzh, Ekkehart Schmidt, Bruce Bumble, Adriana E Lita, Andrew D Beyer, Jason P Allmaras, Ryan M Briggs, Alexander G Kozorezov, Emma E Wollman, Matthew D Shaw, Karl K Berggren

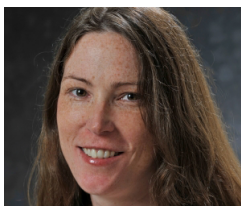
[Nano Lett. 2022, 22, 14, 5667–5673 \(2022\)](#)

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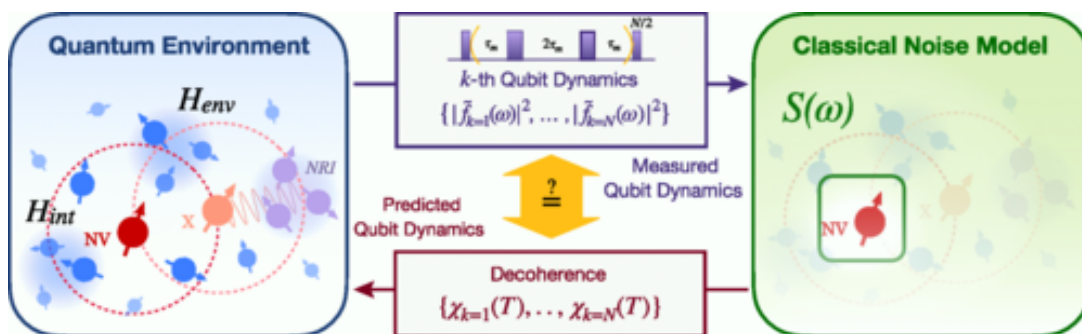
RAFAEL GOMEZ-BOMBARELLI, DMSE

“Thermal half-lives of azobenzene derivatives: virtual screening based on inter-system crossing using a machine learning potential”Simon Axelrod, Eugene Shakhnovich, Rafael Gómez-Bombarelli
[arXiv:2207.11592 \(2022\)](https://arxiv.org/abs/2207.11592)

DANIELLE BRAJE, Lincoln Laboratory

“A Solid-State Microwave Magnetometer with Picotesla-Level Sensitivity”Scott T. Alsid, Jennifer M. Schloss, Matthew H. Steinecker, John F. Barry, Andrew C. Maccabe, Guoqing Wang, Paola Cappellaro, Danielle A. Braje
[arXiv:2206.15440 \(2022\)](https://arxiv.org/abs/2206.15440)

PAOLA CAPPELLARO, NSE

“Self-consistent noise characterization of quantum devices”Won Kyu Calvin Sun and Paola Cappellaro
[Phys. Rev. B 106, 155413 \(2022\)](https://doi.org/10.1103/PhysRevB.106.155413) | [arXiv:2210.09370 \(2022\)](https://arxiv.org/abs/2210.09370)

Reducing a quantum environment to a self-consistent classical noise model. To model a quantum environment, we attempt to develop a classical noise model $S(\omega)$ that is consistent with the set of all observed decoherence under various controlled dynamics. When such a “self-consistent” noise model is possible, as demonstrated in this paper experimentally for an NV electronic spin in diamond but not a nearby interacting electronic spin X several nanometers away, we further verify that the self-consistent model has predictive power even under new dynamics, confirming that it accurately models the underlying quantum bath.

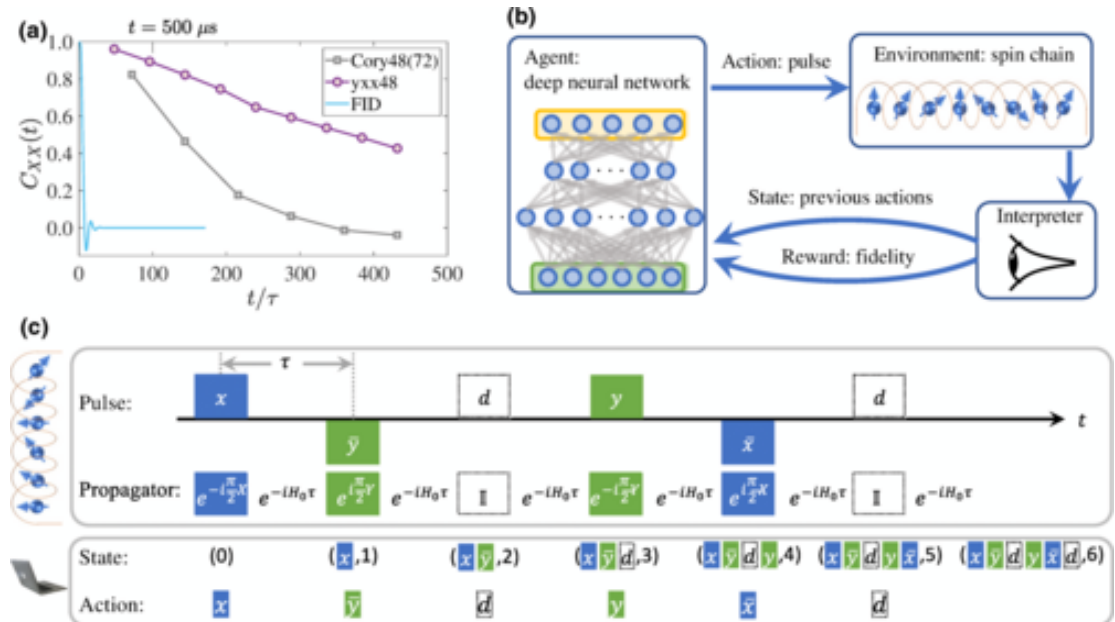
“Exploiting disorder to probe spin and energy hydrodynamics”Pai Peng, Bingtian Ye, Norman Y Yao, Paola Cappellaro
[arxiv.2209.09322 \(2022\)](https://arxiv.org/abs/2209.09322)

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PAOLA CAPPELLARO, NSE

“Deep Reinforcement Learning for Quantum Hamiltonian Engineering”

Pai Peng, Xiaoyang Huang, Chao Yin, Linta Joseph, Chandrasekhar Ramathan, and Paola Cappellaro

[Phys. Rev. Applied 18, 024033 \(2022\)](#)

(a) Quantum dynamics characterized by the decay of x correlation, $C_{XX} = \text{Tr}(X(t)X)/2L$ with $X = \sum_j S_j^x$, under free evolution (no pulses, blue curve), and with rf pulse sequences, Cory48 (gray curve) and yxx48 obtained from RL (purple curve). Parameters can be found in Fig. 3 below. (b) High-level RL protocol for Hamiltonian engineering. The agent, realized as a deep neural network, takes an action based on the current state. This action applies the corresponding control operation to the spin chain. The interpreter updates the state based on the chosen action, and feeds it to the agent to take the next action. When the final time is reached, the interpreter calculates the reward, which is then used to optimize the agent. (c) States and actions, and corresponding quantum operations, illustrated using the WAHUA sequence [2], which can be discretized into six time steps. Here $x, \bar{x}, y, \bar{y}$ in the colored blocks denote $\pi/2$ pulses along $x, -x, y, -y$, respectively; d in the dashed blocks denotes no pulse action (delay). The propagators of pulses shown in (c) correspond to infinitely short pulses (δ pulses). For an x pulse with finite width t_w , the propagator should be $e^{-i\pi X/2} e^{-iH_0 t_w}$, and similarly for pulses along other axes.

MICHAEL CARBIN, EECS

“Pruning’s Effect on Generalization Through the Lens of Training and Regularization”

Tian Jin, Michael Carbin, Daniel M Roy, Jonathan Frankle, Gintare Karolina Dziugaite

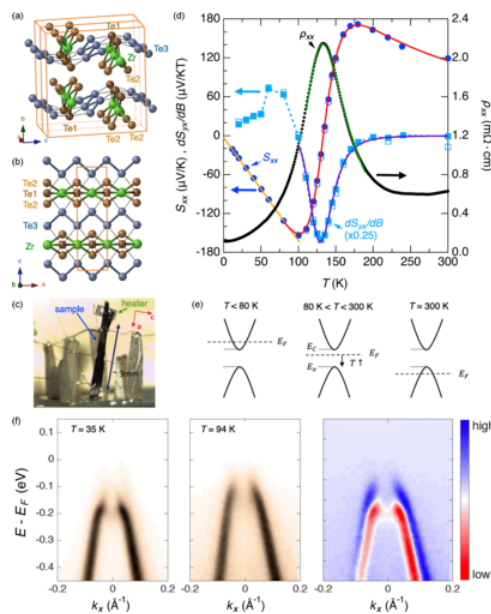
[arxiv:2210.13738 \(2022\)](#)

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MICHAEL CARBIN, EECS

“Semi-Symbolic Inference for Efficient Streaming Probabilistic Programming”Eric Atkinson, Charles Yuan, Guillaume Baudart, Louis Mandel, Michael Carbin
[arxiv:2209.07490](https://arxiv.org/abs/2209.07490) (2022)

JOSEPH CHECKELSKY, Physics

“Band Structure Driven Thermoelectric Response of Topological Semiconductor ZrTe5”Junbo Zhu, Changmin Lee, Fahad Mahmood, Takehito Suzuki, Shiang Fang, Nuh Gedik, Joseph G. Checkelsky
[Phys. Rev. B](https://doi.org/10.1103/PhysRevB.105.121401) (2022) | [arXiv:2205.10394](https://arxiv.org/abs/2205.10394) (2022)

(a), (b) Crystal structure of layered compound ZrTe5. (c) Photo of thermoelectric measurement setup. (d) Resistivity and thermoelectric response for the zero magnetic field limit. The solid and open blue circles (cyan squares) of S_{xx} (S_{yx}) refer to data with heater power 0.25 and 0.5 mW. Solid lines in (d) are fittings according to the Fermi level shifting model sketched in (e) (see text). (f) ARPES energy-momentum cuts across the Γ point taken at temperatures of 35 K (left) and 94 K (middle); darker color denotes higher intensity. The intensity difference (high temperature minus low temperature) is shown in the rightmost panel.

“Methods for Multi-Layer van der Waals Heterostructures Topological Materials Discovery via STEM and LEEM”David C. Bell, Cigdem Ozsoy Keskinbora, Austin Akey, Aravind Devarakonda, Liang Fu, Efthimios Kaxiras, Joseph Checkelsky
[Microscopy and Microanalysis](https://doi.org/10.1103/PhysRevX.12.011011) 28(S1):1702-1703 (2022)**“Snapshots of a light-induced metastable hidden phase driven by the collapse of charge order”**Frank Y Gao, Zhuquan Zhang, Zhiyuan Sun, Linda Ye, Yu-Hsiang Cheng, Zi-Jie Liu, Joseph G Checkelsky, Edoardo Baldini, Keith A Nelson
[Science Advances](https://doi.org/10.1126/science.1251111) (2022) | [arxiv:2112.11015](https://arxiv.org/abs/2112.11015) (2021)



AROUND THE INSTITUTE

SOONWON CHOI, Physics

“Enhancing Detection of Topological Order by Local Error Correction”

Iris Cong, Nishad Maskara, Minh C Tran, Hannes Pichler, Giulia Semeghini, Susanne F Yelin, Soonwon Choi, Mikhail D Lukin

[arxiv:2209.12428 \(2022\)](#)**“Controlling local thermalization dynamics in a Floquet-engineered dipolar ensemble”**

Leigh S Martin, Hengyun Zhou, Nathaniel T Leita, Nishad Maskara, Oksana Makarova, Haoyang Gao, Qian-Ze Zhu, Mincheol Park, Matthew Tyler, Hongkun Park, Soonwon Choi, Mikhail D Lukin

[arxiv:2209.09297 \(2022\)](#)**“A universal crossover in quantum circuits governed by a proximate classical error correction transition”**

Anasuya Lyons, Soonwon Choi, Ehud Altman

[arXiv:2208.02217 \(2022\)](#)**“Classically verifiable quantum advantage from a computational Bell test”**

Gregory D Kahanamoku-Meyer, Soonwon Choi, Umesh V Vazirani, Norman Y Yao

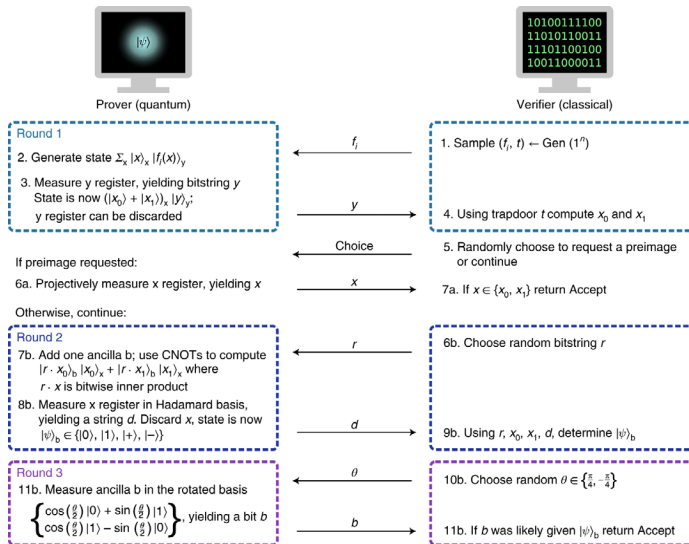
[Nature Physics 2022](#) | [arXiv:2104.00687 \(2021\)](#)

Fig. 1: Schematic representation of the interactive quantum advantage protocol. In the first round of interaction, the classical verifier (right) selects a specific function from a trapdoor claw-free family and the quantum prover (left) evaluates it over a superposition of inputs. The goal of the second round is to condense the information contained in the prover's superposition state onto a single ancilla qubit. The final round of interaction effectively performs a Bell inequality measurement, the outcome of which is cryptographically protected.

“Probing dynamics of a two-dimensional dipolar spin ensemble using single qubit sensor”

Kristine Rezai, Soonwon Choi, Mikhail D. Lukin, Alexander O. Sushkov

[arXiv:2207.10688 \(2022\)](#)

SOONWON CHOI, Physics



"Landau-Forbidden Quantum Criticality in Rydberg Quantum Simulators"

Jong Yeon Lee, Joshua Ramette, Max A. Metlitski, Vladan Vuletic, Wen Wei Ho, Soonwon Choi

[arXiv:2207.08829 \(2022\)](#)

"A scalable superconducting quantum simulator with long-range connectivity based on a photonic bandgap metamaterial"

Xueyue Zhang, Eunjong Kim, Daniel K. Mark, Soonwon Choi, Oskar Painter

[arXiv:2206.12803 \(2022\)](#)

"Classically-Verifiable Quantum Advantage from a Computational Bell Test"

Gregory D. Kahanamoku-Meyer, Soonwon Choi, Umesh V. Vazirani, Norman Y. Yao

[arXiv:2104.00687 \(2022\)](#)

"Emergent Quantum Randomness and Benchmarking from Hamiltonian Many-body Dynamics"

Joonhee Choi, Adam L. Shaw, Ivaylo S. Madjarov, Xin Xie, Ran Finkelstein, Jacob P. Covey, Jordan S. Cotler, Daniel K. Mark, Hsin-Yuan Huang, Anant Kale, Hannes Pichler, Fernando G.S.L. Brandão, Soonwon Choi, Manuel Endres

[arXiv:2103.03535 \(2022\)](#)

"Benchmarking Quantum Simulators using Quantum Chaos"

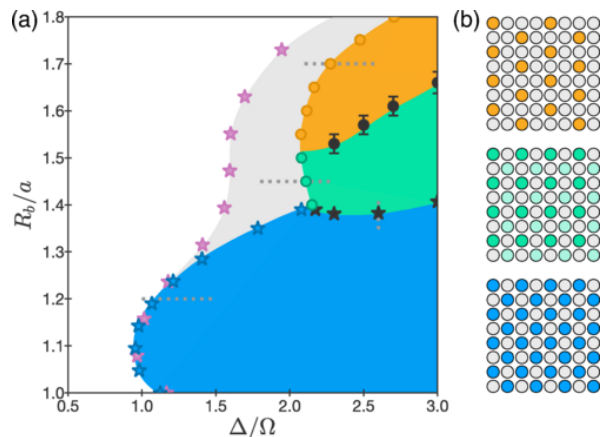
Daniel K. Mark, Joonhee Choi, Adam L. Shaw, Manuel Endres, Soonwon Choi

[arXiv:2205.12211 \(2022\)](#)

"Bulk and boundary quantum phase transitions in a square Rydberg atom array"

Marcin Kalinowski, Rhine Samajdar, Roger G Melko, Mikhail D Lukin, Subir Sachdev, Soonwon Choi

[Physics Review B \(2022\)](#) | [arXiv:2112.10790 \(2021\)](#)



(a) Quantum phase diagram: First- and second-order QPTs are denoted by the circle and star markers, respectively. Purple stars mark boundary transitions in systems with OBC. The shaded area marks the region where the system lies in the disordered phase when using PBC but exhibits a boundary-ordered phase with OBC. The gray dashed lines indicate parameter ranges investigated in Figs. 2 and 4. (b) Schematic pictures of three distinct density-wave orders corresponding to the star (orange), striated (green), and checkerboard (blue) phases. Filled sites denote Rydberg excitations while gray sites represent ground-state atoms.



“Magnetic Excitations in Strained Infinite-layer Nickelate PrNiO₂”

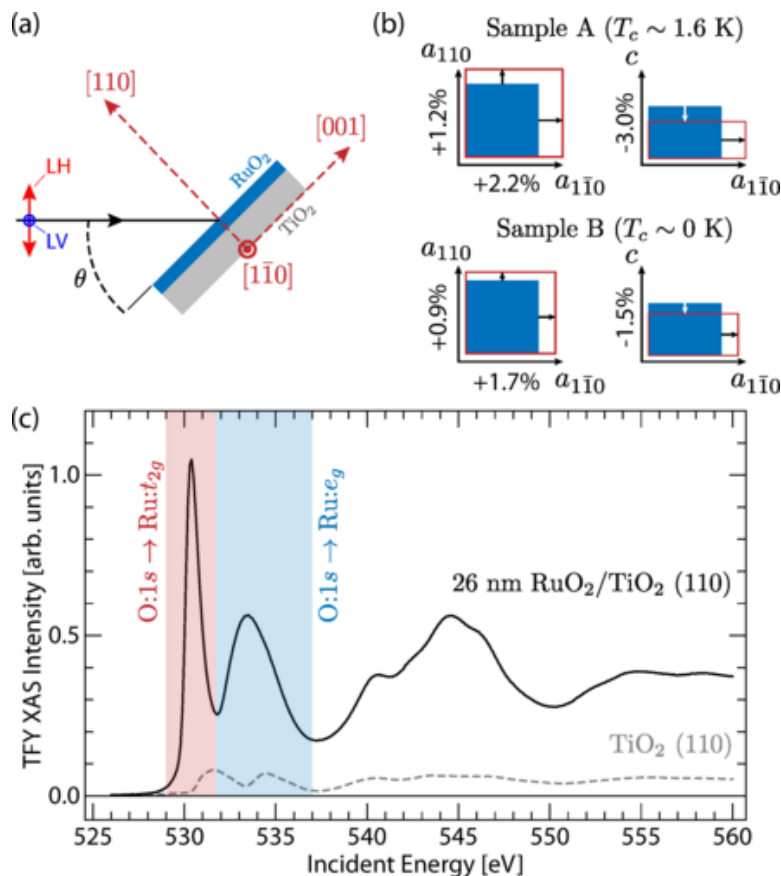
Qiang Gao, Shiyu Fan, Qisi Wang, Jiarui Li, Xiaolin Ren, Izabela Biało, Annabella Drewanowski, Pascal Rothenbühler, Jaewon Choi, Yao Wang, Tao Xiang, Jiangping Hu, Ke-Jin Zhou, Valentina Bisogni, Riccardo Comin, J Chang, Jonathan Pelliciari, XJ Zhou, Zhihai Zhu

[arXiv:2208.05614 \(2022\)](#)

“Strain-modulated anisotropic electronic structure in superconducting RuO₂ films”

Connor A. Occhialini, Luiz G. P. Martins, Shiyu Fan, Valentina Bisogni, Takahiro Yasunami, Maki Musashi, Masashi Kawasaki, Masaki Uchida, Riccardo Comin, and Jonathan Pelliciari

[Phys. Rev. Materials \(2022\)](#) | [arXiv:2208.00718 \(2022\)](#)



Crystallographic orientation, scattering geometry and polarization states (LH/LV) used for the experiments. (b) Schematic of the strain states for the samples: superconducting film (sample A) and nonsuperconducting film (sample B). (c) Oxygen K-edge absorption spectrum in total fluorescence yield (TFY) for sample A at $\theta=15$ degrees and LH polarization compared to the absorption spectrum of the bare TiO₂ substrate.

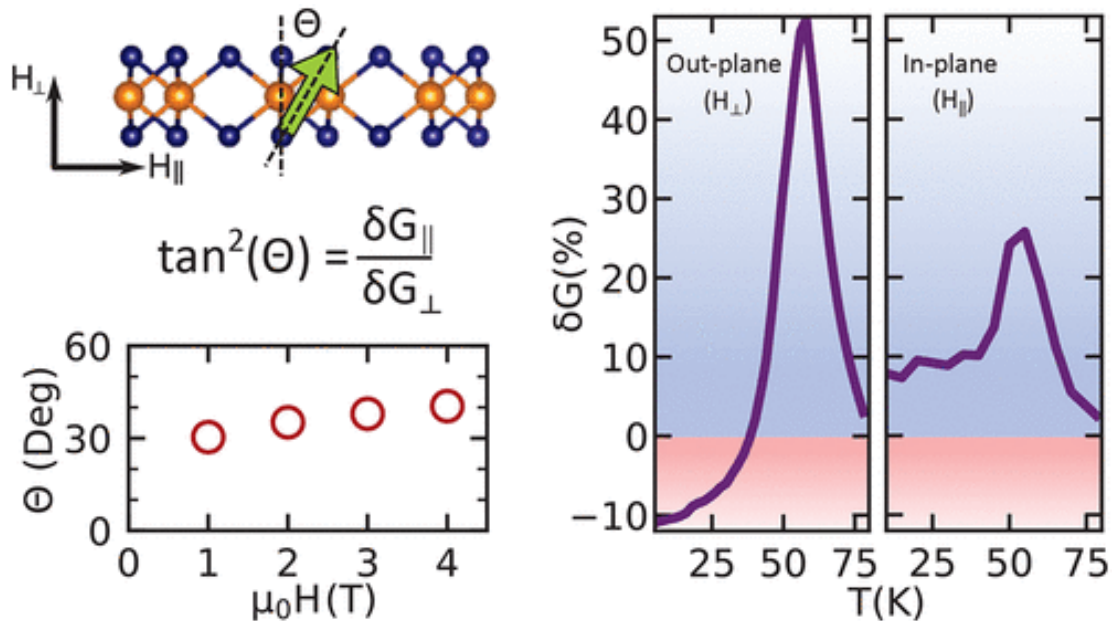
AROUND THE INSTITUTE

RICCARDO COMIN, Physics

“Probing Magnetism in Exfoliated VI₃ Layers with Magnetotransport”

David Soler-Delgado, Fengrui Yao, Dumitru Dumcenco, Enrico Giannini, Jiaruo Li, Connor A. Occhialini, Riccardo Comin, Nicolas Ubrig, and Alberto F. Morpurgo

[Nano Lett. \(2022\)](#) | [ResearchGate \(2022\)](#)

**“Unconventional Charge-density-wave Order in a Dilute d-band Semiconductor”**

Huandong Chen, Batyr Ilyas, Boyang Zhao, ..., Riccardo Comin, et. al
[arXiv:2207.11622 \(2022\)](#)

DANE W. DEQUILLETES, Lincoln Laboratory

“Mapping the Diffusion Tensor in Microstructured Perovskites”

Roberto Brenes, Dane W deQuilletes, Richard Swartwout, Abdullah Y Alsalloum, Osman M Bakr, Vladimir Bulović
[arXiv:2209.08684 \(2022\)](#)



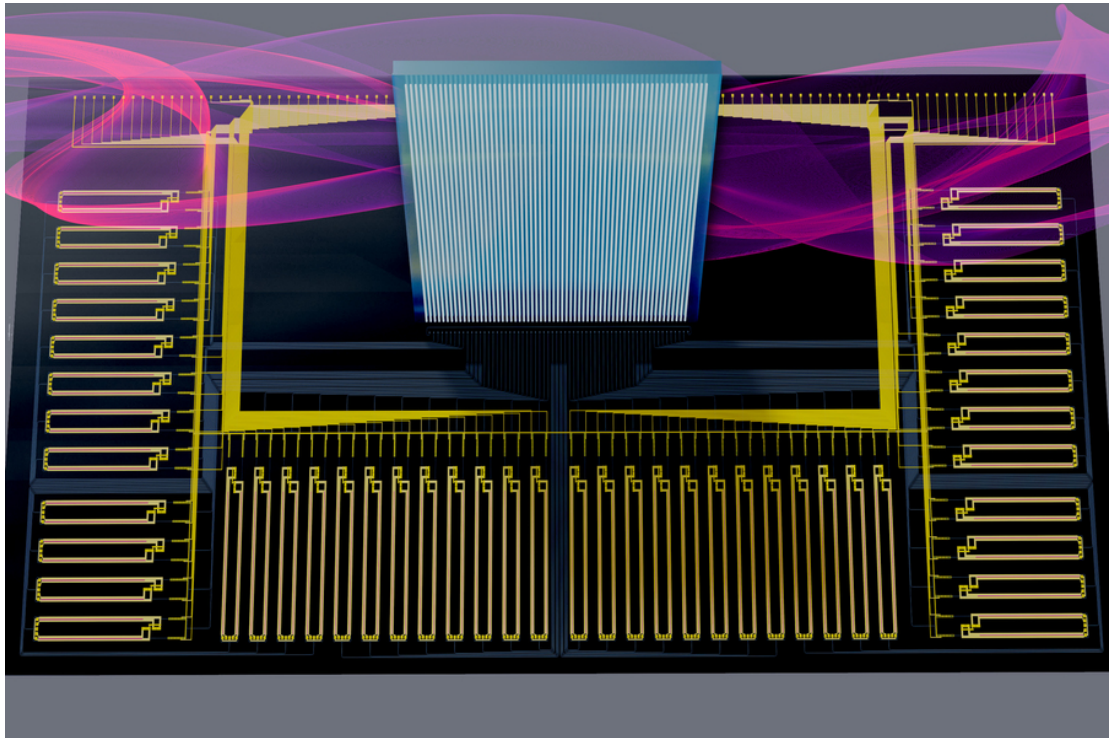
AROUND THE INSTITUTE

DIRK ENGLUND, EECS

“Delocalized Photonic Deep Learning on the Internet’s Edge”

Alexander Sludds, Saumil Bandyopadhyay, Zaijun Chen, Zhizhen Zhong, Jared Cochrane, Liane Bernstein, Darius Bunandar, P Ben Dixon, Scott Hamilton, Matthew Streshinsky, Ari Novack, Tom Baehr-Jones, Michael Hochberg, Manya Ghobadi, Ryan Hamerly, Dirk Englund

[MIT News](#) | [Science](#) | [arXiv:2203.05466 \(2022\)](#)



This rendering shows a novel piece of hardware called a smart transceiver, that uses technology known as silicon photonics to dramatically accelerate one of the most memory-intensive steps of running a machine-learning model.

“Resource-efficient simulation of noisy quantum circuits and application to network-enabled QRAM optimization”

Luís Bugalho, Emmanuel Zambrini Cruzeiro, Kevin C Chen, Wenhan Dai, Dirk Englund, Yasser Omar

[arXiv:2210.13494 \(2022\)](#)

“Large-scale optical characterization of solid-state quantum emitters”

Luís Bugalho, Emmanuel Zambrini Cruzeiro, Kevin C Chen, Wenhan Dai, Dirk Englund, Yasser Omar

[arXiv:2210.13643 \(2022\)](#)



AROUND THE INSTITUTE

DIRK ENGLUND, EECS

[“Quantum Network Utility: A Framework for Benchmarking Quantum Networks”](#)

Yuan Lee, Wenhan Dai, Don Towsley, Dirk Englund
[arXiv:2210.10752 \(2022\)](#)

[“Transferable Learning on Analog Hardware”](#)

Sri Krishna Vadlamani, Dirk Englund, Ryan Hamerly
[arXiv:2210.06632 \(2022\)](#)

[“Scalable photonic integrated circuits for programmable control of atomic systems”](#)

Adrian J Menssen, Artur Hermans, Ian Christen, Thomas Propson, Andrew J Leenheer, Matthew Zimmermann, Mark Dong, Hugo Larocque, Hamza Raniwala, Gerald Gilbert, Matt Eichenfield, and Dirk R Englund,
[arXiv:2210.03100 \(2022\)](#)

[“Multiplexed control of spin quantum memories in a photonic circuit”](#)

D. Andrew Golter, Genevieve Clark, Tareq El Dandachi, Stefan Krastanov, Andrew J. Leenheer, Noel H. Wan, Hamza Raniwala, Matthew Zimmermann, Mark Dong, Kevin C. Chen, Linsen Li, Matt Eichenfield, Gerald Gilbert, Dirk Englund
[arXiv:2209.11853 \(2022\)](#)

[“Spectrally Selective Thermal Emission from Graphene Decorated with Metallic Nanoparticles”](#)

Jayden Craft, Muhammad Waqas Shabbir, Dirk R. Englund, Richard M. Osgood III, Michael N. Leuenberger
[arXiv:2209.11751 \(2022\)](#)

[“A Self-Similar Sine-Cosine Fractal Architecture for Multiport Interferometers”](#)

Jasvith Raj Basani, Sri Krishna Vadlamani, Saumil Bandyopadhyay, Dirk R. Englund, Ryan Hamerly
[arXiv:2209.03335 \(2022\)](#)

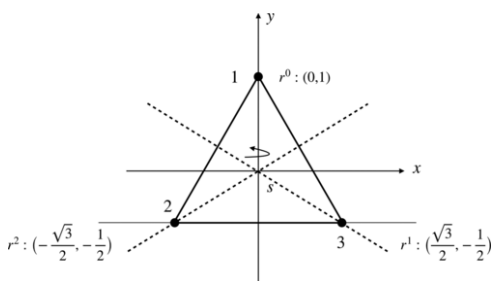
[“Highly-twisted states of light from a high quality factor photonic crystal ring”](#)

Xiyuan Lu, Mingkang Wang, Feng Zhou, Mikkel Heuck, Wenqi Zhu, Vladimir A. Aksyuk, Dirk R. Englund, Kartik Srinivasan
[arXiv:2208.13075 \(2022\)](#)

DIRK ENGLUND, EECS

“Quantum algorithms for group convolution, cross-correlation, and equivariant transformations”

Grecia Castelazo, Quynh T. Nguyen, Giacomo De Palma, Dirk Englund, Seth Lloyd, Bobak T. Kiani

[Phys. Rev. A 106, 032402 \(2022\)](#) | [arXiv:2109.11330 \(2021\)](#)

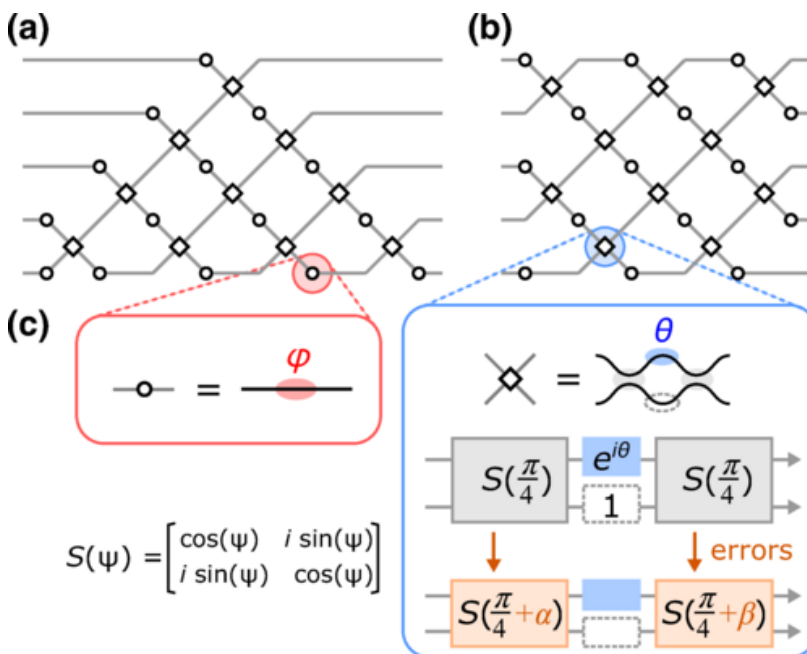
The dihedral group D_3 is the symmetry group of an equilateral triangle; that is, it is the set of all transformations such as reflection, rotation, and combinations of these, that leave the shape and position of this triangle fixed.

“Programmable photonic integrated meshes for modular generation of optical entanglement links”

Mark Dong, Matthew Zimmermann, David Heim, Hyeonrak Choi, Genevieve Clark, Andrew J. Leenheer, Kevin J. Palm, Alex Witte, Daniel Dominguez, Gerald Gilbert, Matt Eichenfield, Dirk Englund

[arXiv:2208.13911 \(2022\)](#)**“Accurate Self-Configuration of Rectangular Multiport Interferometers”**

Ryan Hamerly, Saumil Bandyopadhyay, Dirk Englund

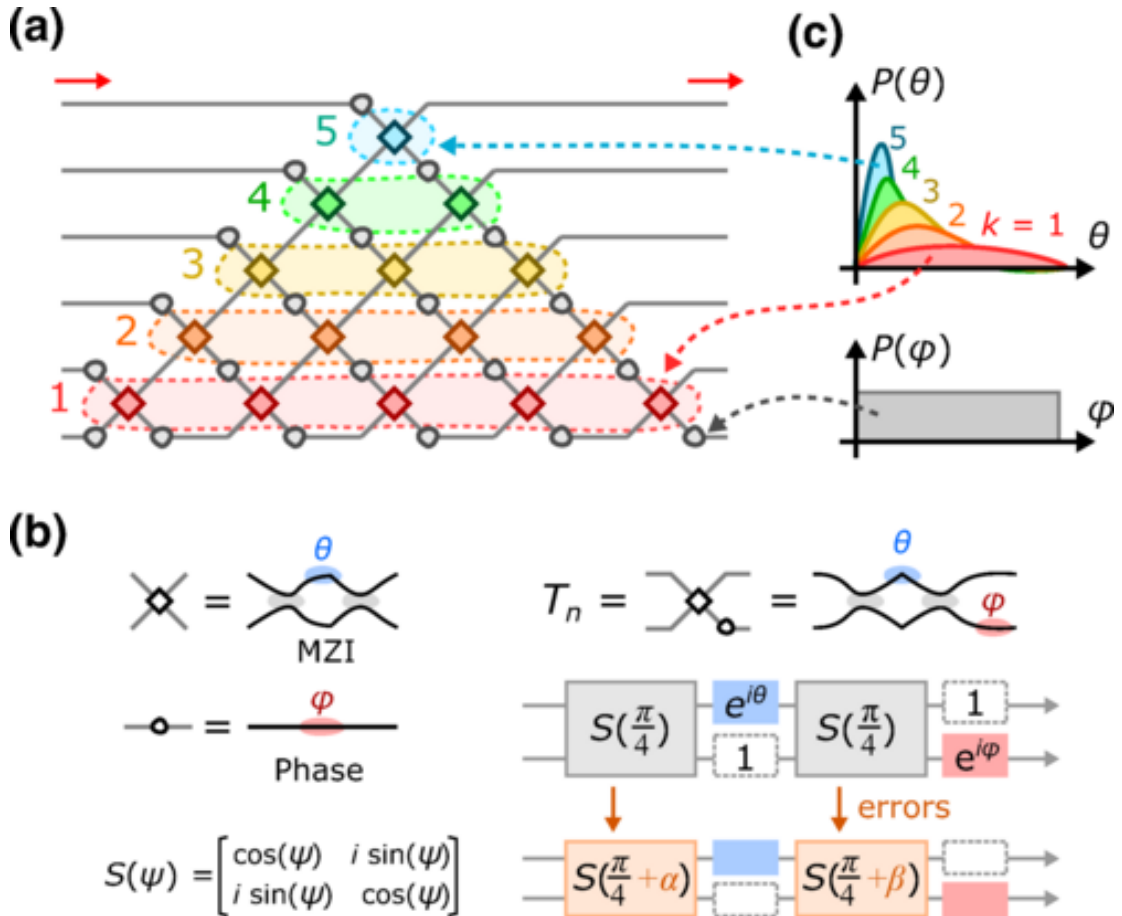
[Phys. Rev. Applied 18, 024019 \(2022\)](#) | [arXiv:2106.03249 \(2021\)](#)



“Stability of Self-Configuring Large Multiport Interferometers”

Ryan Hamerly, Saumil Bandyopadhyay, Dirk Englund

[Phys. Rev. Applied 18, 024018 \(2022\)](#) | [arXiv:2106.04363 \(2021\)](#)



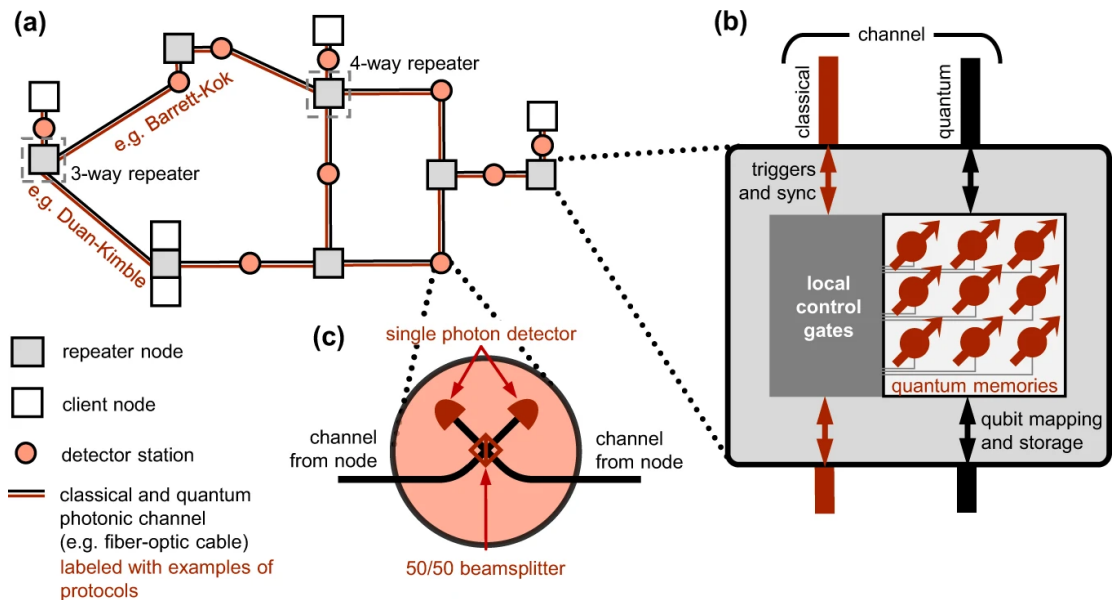
(a) Triangular (Reck) universal multiport interferometer [14]. (b) Constituent components and 2x2 unit cell T_n , illustrating the effect of errors on the transfer matrix. (c) Distribution of splitting angles θ and phase shifts ϕ over the Haar measure, Eqs. (10) and (11).

“An integrated photonic engine for programmable atomic control”

Ian Christen, Madison Sutula, Thomas Propson, Hamed Sattari, Gregory Choong, Christopher Panuski, Alexander Melville, Justin Mallek, Scott Hamilton, P. Benjamin Dixon, Adrian J. Menssen, Danielle Braje, Amir H. Ghadimi, Dirk Englund

[arXiv:2208.06732 \(2022\)](#)

DIRK ENGLUND, EECS

"A Quantum Router Architecture for High-Fidelity Entanglement Flows in Multi-User Quantum Networks"Yuan Lee, Eric Bersin, Axel Dahlberg, Stephanie Wehner, Dirk Englund
[NPJ Quantum Information \(2022\)](#) | [arXiv:2005.01852 \(2020\)](#)

The quantum network comprises client nodes, which end users directly access, and repeater nodes, which connect clients by propagating entanglement through the network. a Physical layer implementation. In the physical layer⁴, repeater nodes may be connected by a variety of entanglement protocols. While all protocols require transmission of an entangled photon through a photonic channel, the specific protocol used in each link determines the physical configuration of these channels (e.g. optical fibers) and measurement devices associated with that link. Possible protocols include the cavity-mediated Duan–Kimble protocol⁹ and the photon emission-based Barrett–Kok⁵ and Cabrillo⁶ protocols. These latter protocols employ an intermediate detector station between nodes to herald successful entanglement. b Components in a repeater node. We classify repeater nodes based on the number of other nodes they connect to: a 4-way and a 3-way repeater are labeled. All adjacent repeater nodes are connected by quantum and classical channels (shown explicitly in black and light red respectively). c Detector station used in the photon emission-based protocols to herald entanglement.

JOSEPH A. FORMAGGIO, Physics

"Snowmass 2021 Topical Report on Synergies in Research at Underground Facilities"Catalina Curceanu, Derek Elsworth, Joe Formaggio, Jan Harms, Daniel Robertson, William Roggenthen, Herb Wang, Sijbrand de Jong, John L. Orrell
[arXiv:2210.03145 \(2022\)](#)**"Search for Lorentz-Invariance Violation with the first KATRIN data"**KATRIN Collaboration, ..., J. Formaggio, et. al
[arXiv:2207.06326 \(2022\)](#)



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JOSEPH A. FORMAGGIO, Physics

“Search for keV-scale Sterile Neutrinos with first KATRIN Data”

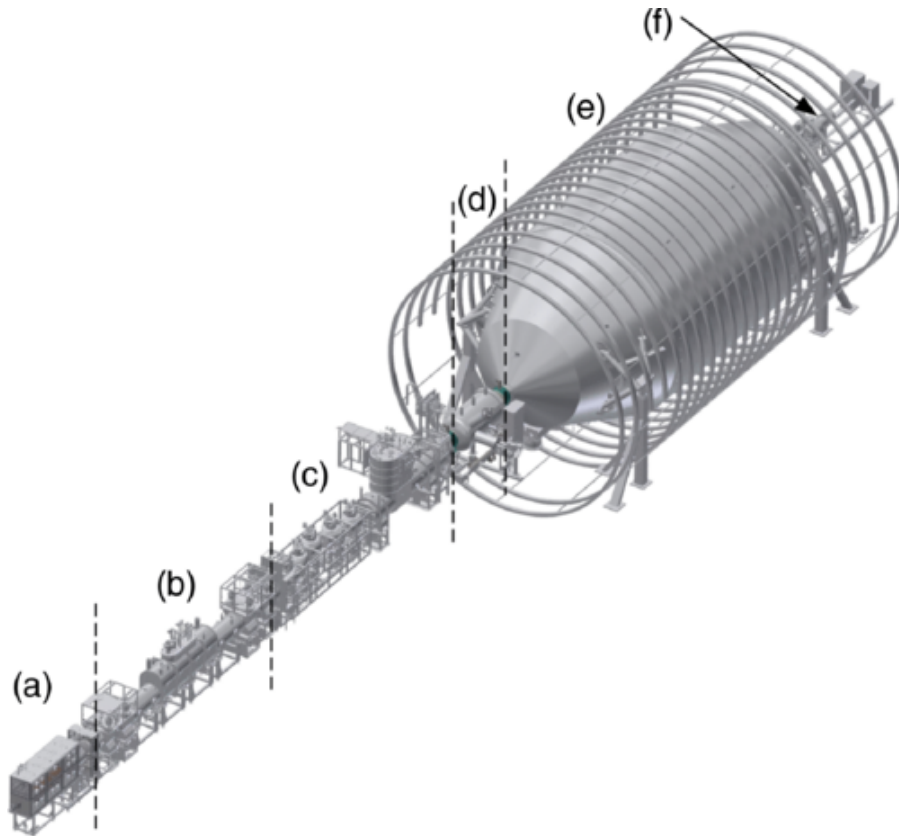
KATRIN Collaboration, ..., J. Formaggio, et. al
[arXiv:2207.06337 \(2022\)](#)

“Fast neutron background characterization of the future Ricochet experiment at the ILL research nuclear reactor”

C. Augier, J. Formaggio, et. al
[arXiv:2208.01760 \(2022\)](#)

“New Constraint on the Local Relic Neutrino Background Overdensity with the First KATRIN Data Runs”

M. Aker, ..., J. Formaggio, et. al
[Phys. Rev. Lett. \(2022\)](#) | [arXiv:2202.04587 \(2022\)](#)



The main components of KATRIN: (a) the rear section, (b) the windowless gaseous tritium source WGTS, (c) the pumping section, and a tandem setup of two MAC-E- filters: (d) the smaller prespectrometer and (e) the larger main spectrometer with surrounding aircoil system. This setup allows only the highest energy β -decay electrons to reach the focal plane detector (f) where they are counted.

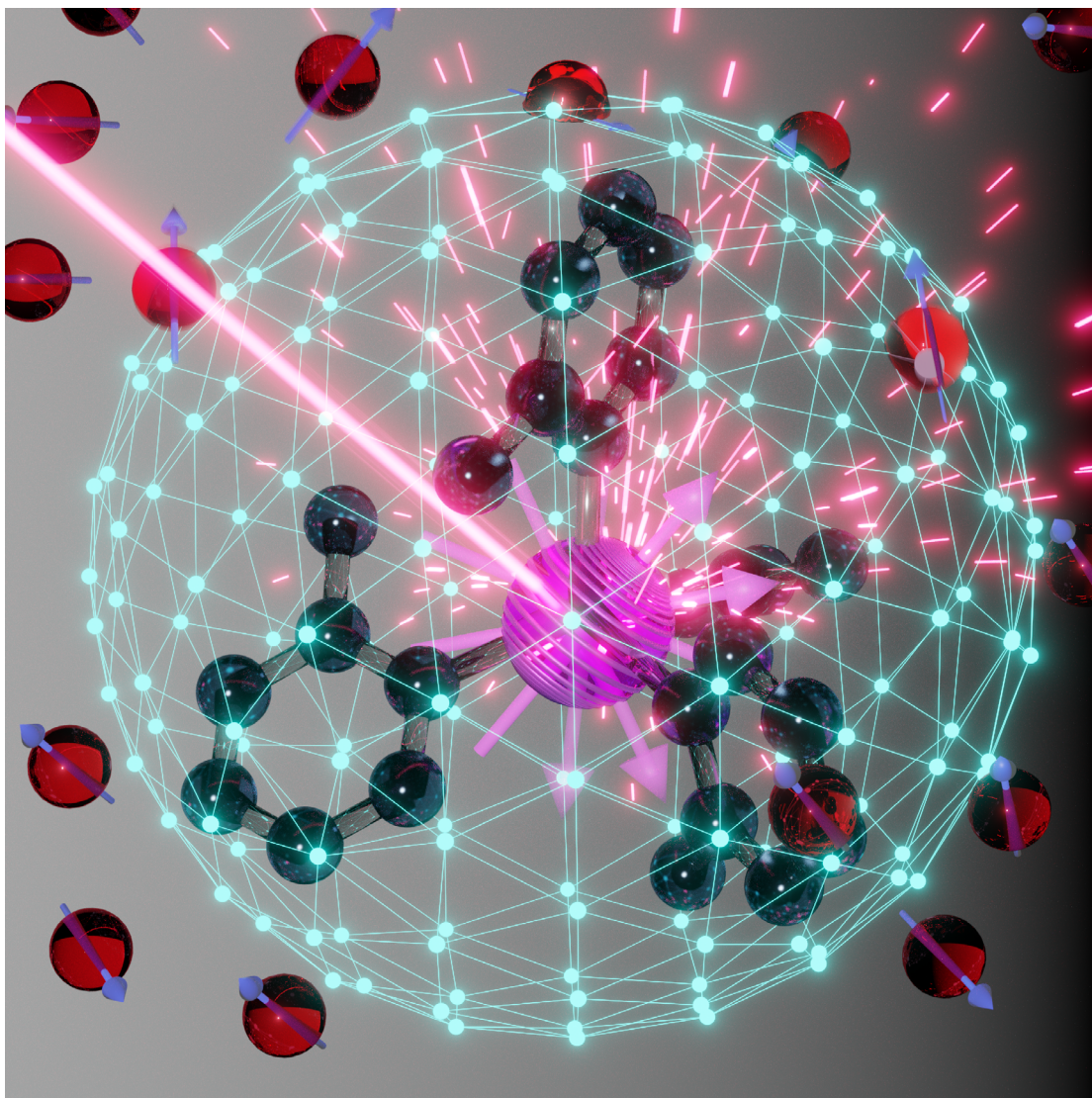
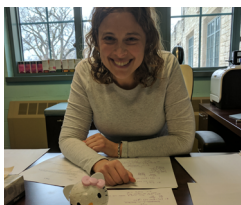
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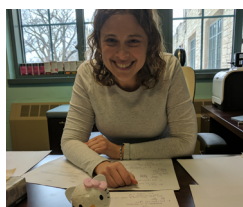
DANNA FREEDMAN, Chemistry

“Enhancing Spin Coherence in Optically Addressable Molecular Qubits through Host-Matrix Control”

S. L. Bayliss, P. Deb, D. W. Laorenza, M. Onizhuk, G. Galli, D. E. Freedman, and D. D. Awschalom

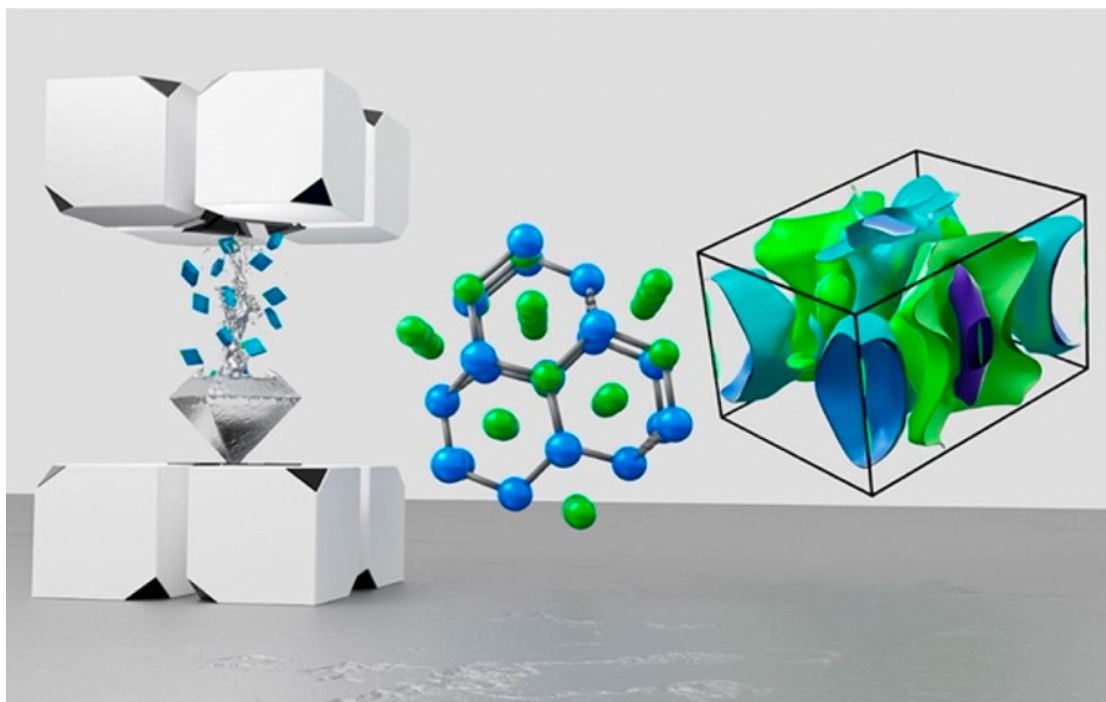
[Phys. Rev. X \(2022\)](#) | [Physics \(2022\)](#) | [arxiv:2204.00168 \(2022\)](#)



**AROUND THE INSTITUTE****DANNA FREEDMAN**, Chemistry**"Synthesis of the Candidate Topological Compound Ni₃Pb₂"**

Alexandra D. Tamerius, Alison B. Altman, Michael J. Waters, Eric A. Riesel, Christos D. Malliakas, Matthew L. Whitaker, Tony Yu, Gilberto Fabbri, Yue Meng, Daniel Haskel, Yanbin Wang, Steven D. Jacobsen, James M. Rondinelli, and Danna E. Freedman

[J. Am. Chem. Soc. \(2022\)](#)

**NUH GEDIK**, Physics**"Dynamics of topological defects after a photo-induced melting of a charge-density wave"**

Andrei E. Tarkhov, A. V. Rozhkov, Alfred Zong, Anshul Kogar, Nuh Gedik, Boris V. Fine

[arXiv:2203.05001 \(2022\)](#)

"Unconventional Charge-density-wave Order in a Dilute d-band Semiconductor"

Huandong Chen, Batyr Ilyas, Boyang Zhao, ..., Riccardo Comin, ..., Nuh Gedik, Jayakanth Ravichandran

[arXiv:2207.11622 \(2022\)](#)

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NUH GEDIK, Physics

“Terahertz Field-Induced Reemergence of Quenched Photoluminescence in Quantum Dots”

Jiaojian Shi, Frank Y. Gao, Zhuquan Zhang, Hendrik Utzat, Ulugbek Barotov, Ardavan Farahvash, Jinchi Han, Jude Deschamps, Chan-Wook Baik, Kyung Sang Cho, Vladimir Bulović, Adam P. Willard, Edoardo Baldini, Nuh Gedik, Mounqi G. Bawendi, Keith A. Nelson

[Nano Lett. 2022, 22, 4, 1718–1725](#) | [arXiv:2112.08533 \(2021\)](#)



MARK GOUKER, Lincoln Laboratory

“Wafer-Scale Characterization of a Superconductor Integrated Circuit Fabrication Process, Using a Cryogenic Wafer Prober”

Joshua T West, Arthur Kurlej, Alex Wynn, Chad Rogers, Mark A Gouker, Sergey K Tolpygo

[leexlore \(2022\)](#) | [arXiv:2112.00705](#)



SCOTT HAMILTON, Lincoln Laboratory

“Scalable Photonic Integration of Long-Lived Tin-Vacancy Memories at 1.3 K”

Ian Christen, Hamza Raniwala, Marco Colangelo, Kevin Chen, Lorenzo De Santis Linsen Li, Yixuan Song, Carlos Errando-Herranz, Isaac Harris, Eric Bersin Madison Sutula, Karl Berggren, Matt Trusheim, Dirk Englund, P. Ben Dixon, Xingyu Zhang, Katia Shtyrkova Dave Kharas, Ryan Murphy, and Scott Hamilton

[Optica \(2022\)](#)



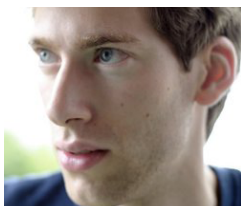
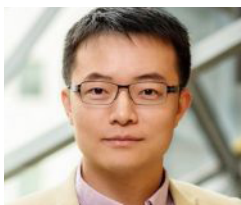
SONG HAN, EECS

“Variational Quantum Pulse Learning”

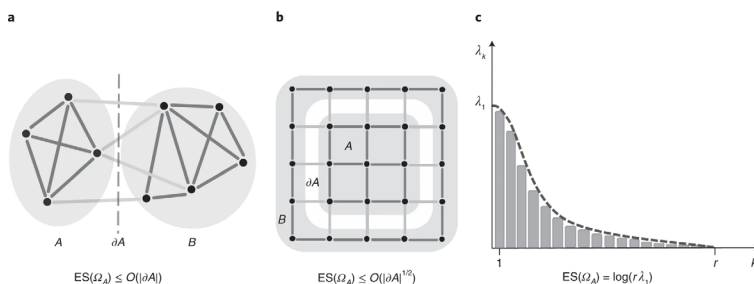
Zhiding Liang, Hanrui Wang, Jinglei Cheng, Yongshan Ding, Hang Ren, Zhengqi Gao, Xuehai Qian, Song Han, Weiwen Jiang, Yiyu Shi

[arXiv:2203.17267 \(2022\)](#)

SONG HAN, EECS

“QOC: Quantum On-Chip Training with Parameter Shift and Gradient Pruning”Hanrui Wang, Zirui Li, Jiaqi Gu, Yongshan Ding, David Z. Pan, Song Han
[arXiv:2202.13239 \(2022\)](#)**“PVNAS: 3D Neural Architecture Search with Point-Voxel Convolution”**Zhijian Liu, Haotian Tang, Shengyu Zhao, Kevin Shao, Song Han
[arXiv:2204.11797 \(2022\)](#)**“PAN: Pulse Ansatz on NISQ Machines”**Zhiding Liang, Jinglei Cheng, Hang Ren, Hanrui Wang, Fei Hua, Yongshan Ding, Fred Chong, Song Han, Yiyu Shi, Xuehai Qian
[arXiv:2208.01215 \(2022\)](#)**“BEVFusion: Multi-Task Multi-Sensor Fusion with Unified Bird's-Eye View Representation”**Zhijian Liu, Haotian Tang, Alexander Amini, Xinyu Yang, Huizi Mao, Daniela Rus, Song Han
[arXiv:2205.13542 \(2022\)](#)

ARAM HARROW, Physics

“Thermalization without eigenstate thermalization”Aram W Harrow, Yichen Huang
[arXiv:2209.09826 \(2022\)](#)**“Entanglement spread area law in gapped ground states”**Anurag Anshu, Aram W Harrow, Mehdi Soleimanifar
[Nature Physics \(2022\)](#)

regions A and B. Up to a smoothing step (explained in the main text) and the entanglement spread across the cut ∂A is defined as $\log(r\lambda_1) \approx \log(\lambda_1/\lambda_r)$. We show that the entanglement spread scales as $O(|\partial A|)$. We improve this to $O(|\partial A|^{1/2})$ for lattice Hamiltonians. In comparison, the area-law conjecture for entanglement entropy asserts that the entropy of the distribution of Schmidt coefficients is bounded by the size of the cut $|\partial A|$, that is, $S(\varrho_A) = O(|\partial A|)$.

a, Interacting quantum systems with a general interaction graph partitioned into two parts A and B (shaded regions) with boundary ∂A . b, A similar partition for a system on a lattice. c, Profile of the eigenvalues (also known as Schmidt coefficients) $\lambda_1, \lambda_2, \dots, \lambda_r$ of the reduced ground state in region A. This distribution fully encodes the information about the bipartite entanglement between particles in



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PABLO JARILLO-HERRERO, Physics

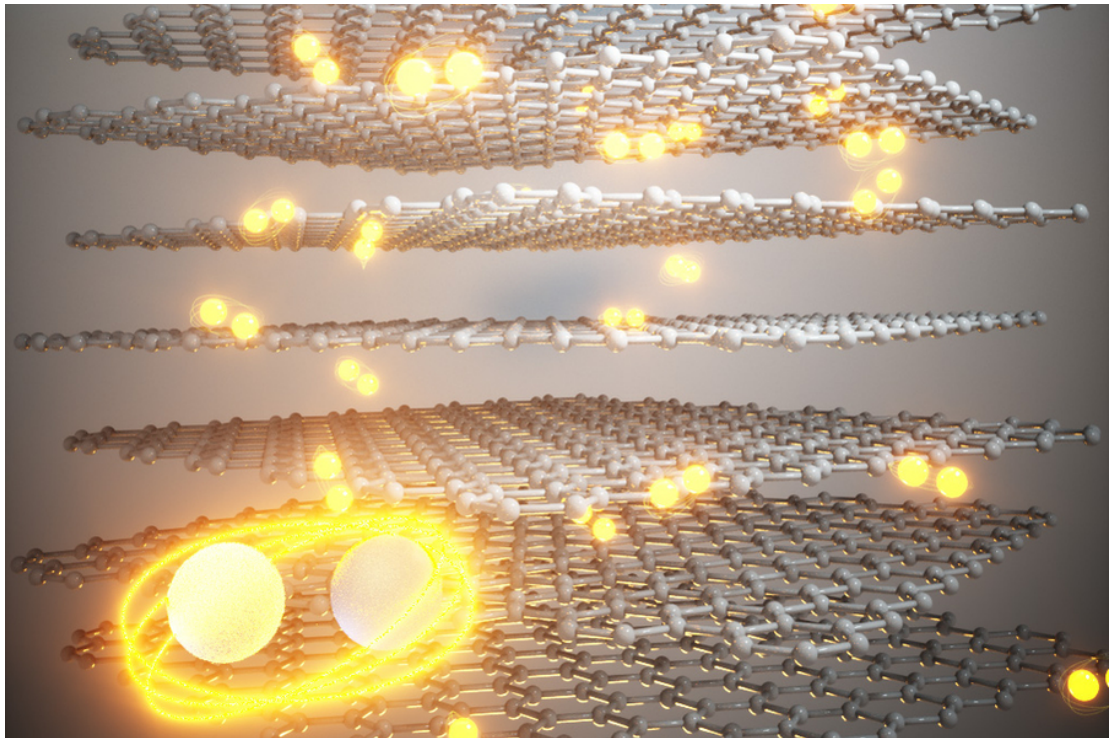
[“Interlayer electron-hole friction in tunable twisted bilayer graphene semimetal”](#)

DA Bandurin, A Principi, IY Phinney, T Taniguchi, K Watanabe, P Jarillo-Herrero
[arXiv:2208.05659 \(2022\)](#)

[“Robust superconductivity in magic-angle multilayer graphene family”](#)

Jeong Min Park, Yuan Cao, Li-Qiao Xia, Shuwen Sun, Kenji Watanabe, Takashi Taniguchi, Pablo Jarillo-Herrero

[MIT News](#) | [Nature Materials \(2022\)](#) | [Nature Materials News & Views](#) | [arXiv:2112.10760 \(2021\)](#)



An illustration showing superconducting Cooper pairs in magic-angle multilayer graphene family. The adjacent layers are twisted in an alternating fashion.

WOLFGANG KETTERLE, Physics

[“Dynamics of Stripe Patterns in Supersolid Spin-Orbit-Coupled Bose Gases”](#)

Kevin T. Geier, Giovanni I. Martone, Philipp Hauke, Wolfgang Ketterle, Sandro Stringari

[arXiv:2210.10064 \(2022\)](#)

WOLFGANG KETTERLE, Physics



“Spin dynamics dominated by superexchange via virtual molecules”

Yoo Kyung Lee, Hanzhen Lin, Wolfgang Ketterle

[arXiv:2208.06054](https://arxiv.org/abs/2208.06054) (2022)

“A Feshbach resonance in collisions between ultracold ground state molecules”

Juliana J. Park, Yu-Kun Lu, Alan O. Jamison, Timur Tscherbul, Wolfgang Ketterle

[arXiv:2208.05557](https://arxiv.org/abs/2208.05557) (2022)

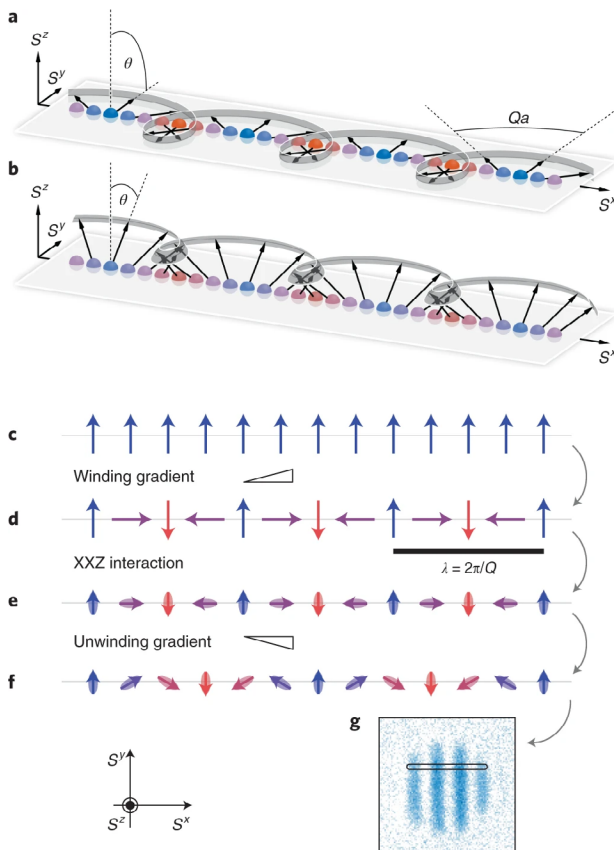
“Perspectives and Opportunities: A Molecular Toolkit for Fundamental Physics and Matter Wave Interferometry in Microgravity”

Jose P. D’Incao, Jason R. Williams, Naceur Gaaloul, Maxim A. Efremov, Stefan Nimmrichter, Bjorn Schrinski, Ethan Elliott, Wolfgang Ketterle

[arXiv:2207.00673](https://arxiv.org/abs/2207.00673) (2022)

“Long-lived phantom helix states in Heisenberg quantum magnets”

Paul Niklas Jepsen, Yoo Kyung Lee, Hanzhen Lin, Ivana Dimitrova, Yair Margalit, Wen Wei Ho, Wolfgang Ketterle

[Nature Physics](https://doi.org/10.1038/s41567-022-01204-3) (2022) | [arXiv:2110.12043](https://arxiv.org/abs/2110.12043)

a–g, We prepare a transverse spin helix where the spin vector winds within the S_x – S_y plane with $\theta = \pi/2$ (a) or with arbitrary polar angle θ (b). Black arrows indicate the direction of the spins of the atoms (spheres) aligned along $+S_y$ (blue), $-S_y$ (red) or intermediate directions (purple); grey ribbon is to guide the eye. An initially spin-polarized state in the S_y direction (c) is wound into a spin helix with variable wavevector Q using a magnetic field gradient (black triangles). Here, we illustrate a winding of $Qa = \pi/2$ (d). This state evolves under the XXZ Heisenberg Hamiltonian (e). After unwinding the remaining spin modulation to a resolvable wavevector (f), the local S_y magnetization is imaged in situ (g) where dark blue indicates spins along $+S_y$. Only the S_x and S_y components of the spin are shown in c–f.

AROUND THE INSTITUTE**WOLFGANG KETTERLE**, Physics**“Fast optical transport of ultracold molecules over long distances”**

Yicheng Bao, Scarlett S. Yu, Loïc Anderegg, Sean Burchesky, Derick Gonzalez-Acevedo, Eunmi Chae, Wolfgang Ketterle, Kang-Kuen Ni, John M. Doyle
[New Journal of Physics \(2022\)](#) | [arXiv:2205.06334 \(2022\)](#)

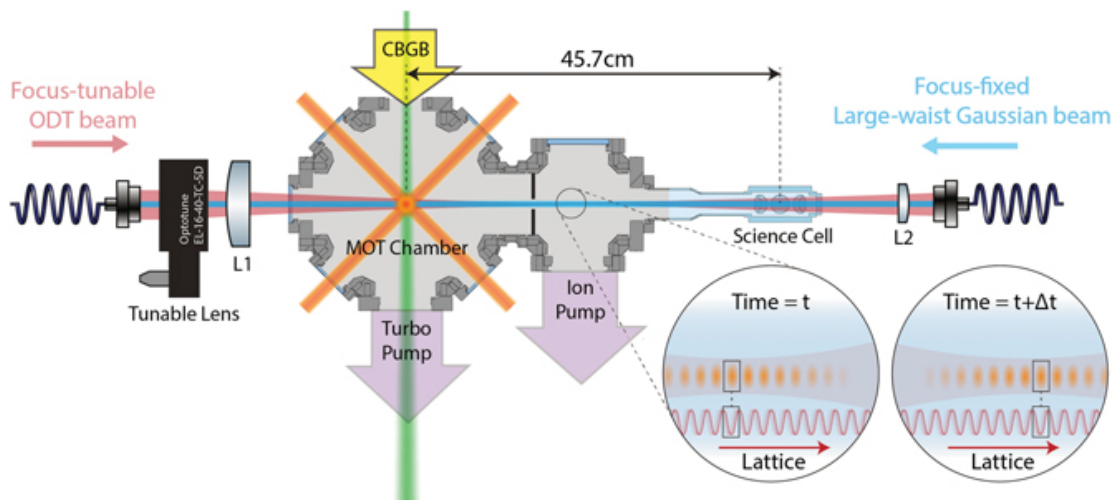


Figure 1. Experiment setup. The yellow arrow indicates the direction of molecular beam from the CBGB source. Purple arrows denote the vacuum pumps to remove helium buffer gas from the chamber. The orange beams are the MOT beams. The green beam is the slowing beam. The blue beam is the large-waist Gaussian beam, propagating from science cell to MOT chamber direction. The pink beam is the focus-tunable small-waist ODT beam, propagating from MOT chamber to science cell direction. The thick black line between MOT chamber and pumping manifold is the differential pumping aperture. The inset shows a configuration in which the lattice is moving toward the science cell, while the tunable lens focus tracks the position of the molecules during one-way transport. The beam diameter and divergence are not scaled and are for illustration only.

JU LI, NSE MSE**“Carbothermal Shock Synthesis of High Entropy Oxide Catalysts: Dynamic Structural and Chemical Reconstruction Boosting the Catalytic Activity and Stability toward Oxygen Evolution Reaction”**

Ali Abdelhafiz, Baoming Wang, Avetik R Harutyunyan, Ju Li
[Advanced Energy Materials \(2022\)](#)

“Pressureless two-step sintering of ultrafine-grained refractory metals: Tungsten-rhenium and molybdenum”

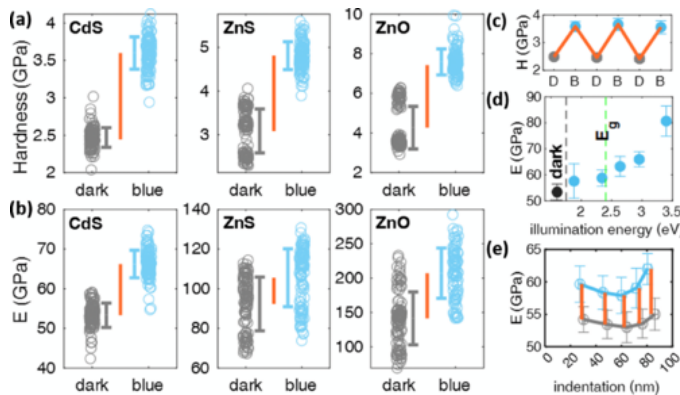
Z Que, Z Wei, X Li, L Zhang, Y Dong, M Qin, J Yang, X Qu, J Li
[Journal of Materials Science & Technology \(2022\)](#)



“Giant and Controllable Photoplasticity and Photoelasticity in Compound Semiconductors”

Jiahao Dong, Yifei Li, Yuying Zhou, Alan Schwartzman, Haowei Xu, Bilal Azhar, Joseph Bennett, Ju Li, and R. Jaramillo

[MIT News](#) | [Phys. Rev. Lett \(2022\)](#) | [Physics \(2022\)](#)



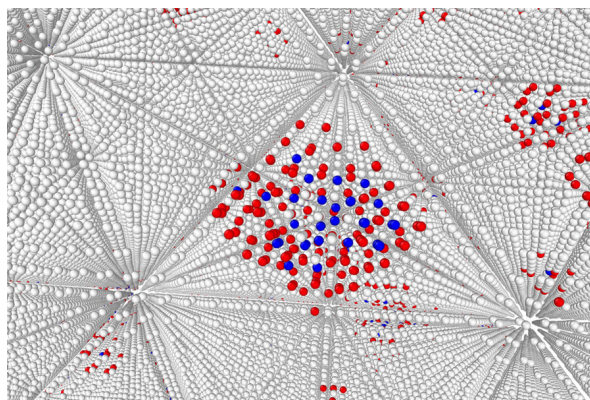
Giant optomechanical effects in wide-band-gap II-VI compounds measured by nanoindentation. (a) Hardness and (b) Young's modulus (E) measured in the dark and under blue illumination by an LED with center wavelength 470 nm; irradiance at the sample surface is 1.4 mW/cm². The data shown include three successive cycles of darkness or illumination, and at each condition the measurement is repeated at 36 distinct locations, for a total of 108 separate measurements each for dark and illuminated conditions. The individual data are plotted directly; error bars report average and standard deviation. Orange bars

indicate the average change between dark and illuminated conditions. (c)–(e) Additional details provided for measurements on CdS. (c) Hardness during successive conditions of dark (D) and blue illumination (B). The data and error bars report the average and standard deviation of the 36 measurements performed at each condition; orange line traces the averages. (d) Dependence of E on the color of illumination, from red to uv; result of measurements in the dark are also shown. The irradiance is different for each condition: red (660 nm, 1.9 eV)=3.3 mW/cm²; green (530 nm, 2.3 eV)=0.9 mW/cm²; blue (470 nm, 2.6 eV)=1.4 mW/cm²; violet (420 nm, 3.0 eV)=1.9 mW/cm²; uv (365 nm, 3.4 eV)=22 mW/cm². (e) Depth dependence of the photoelastic effect, showing dark conditions (gray) and blue illumination (blue); illumination conditions are as in (a)–(c). Error bars on individual points represent the standard deviation of repeated measurements, and the solid lines are guides to the eye. The orange vertical bars indicate the photoelastic effect.

“Revealing hidden defects through stored energy measurements of radiation damage”

Charles A Hirst, Fredric Granberg, Boopathy Kombariah, Penghui Cao, Scott Middlemas, R Scott Kemp, Ju Li, Kai Nordlund, Michael P Short

[MIT News](#) | [Science Advances \(2022\)](#) | [arXiv:2109.15138 \(2022\)](#)



Much of the damage inside nuclear reactor is so small that it has eluded previous tests. Now a new tool provides a way to directly measure the damage, potentially opening a path for the safe operation of nuclear power plants far beyond their present licensed lifetimes.



AROUND THE INSTITUTE

JU LI, NSE MSE

“Thermoelectric power generation in the core of a nuclear reactor”

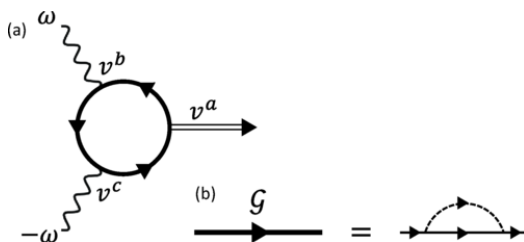
Nicholas Kempf, Mortaza Saeidi-Javash, Haowei Xu, Sheng Cheng, Megha Dubey, Yaqiao Wu, Joshua Daw, Ju Li, Yanliang Zhang
[Energy Conversion and Management \(2022\)](#)

“An Unbalanced Battle in Excellence: Revealing Effect of Ni/Co Occupancy on Water Splitting and Oxygen Reduction Reactions in Triple-Conducting Oxides for Protonic Ceramic Electrochemical Cells”

Wei Tang, Hanping Ding, Wenjuan Bian, Clarita Y Regalado Vera, Joshua Y Gomez, Yanhao Dong, Ju Li, Wei Wu, Weiwei Fan, Meng Zhou, Colin Gore, Bryan M Blackburn, Hongmei Luo, Dong Ding
[Small \(2022\)](#)

“Nonlinear nonreciprocal photocurrents under phonon dressing”

Haowei Xu, Hua Wang, and Ju Li
[Phys. Rev. B \(2022\)](#) | [arXiv:2207.01576 \(2022\)](#)



(a) Feynman diagram of the BPV process. (b) Electron propagator under phonon dressing. Thick (thin) solid arrow: dressed (undressed) electron propagator. Wavy line: photon propagator. Dashed arrow: phonon propagator. Double arrow: charge current output.

“Intelligent disassembly of electric-vehicle batteries: a forward-looking overview”

Kai Meng, Guiyin Xu, Xianghui Peng, Kamal Youcef-Toumi, Ju Li
[Conservation and Recycling \(2022\)](#)

“Transverse and Longitudinal Degradations in Ceramic Solid Electrolytes”

Yanhao Dong, I-Wei Chen, Ju Li
[Chemistry of Materials \(2022\)](#)

“Ultralong one-dimensional plastic zone created in aluminum underneath a nanoscale indent”

Zhi-Yu Nie, Yuji Sato, Shigenobu Ogata, Maria Jazmin Duarte, Gerhard Dehm, Ju Li, Evan Ma, De-Gang Xie, Zhi-Wei Shan
[Acta Materialia \(2022\)](#)

“Enhanced mobility of cations and anions in the redox state: The polaronium mechanism”

Yanhao Dong, Liang Qi, Ana Alvarez, Ju Li, I-Wei Chen
[Acta Materialia \(2022\)](#)

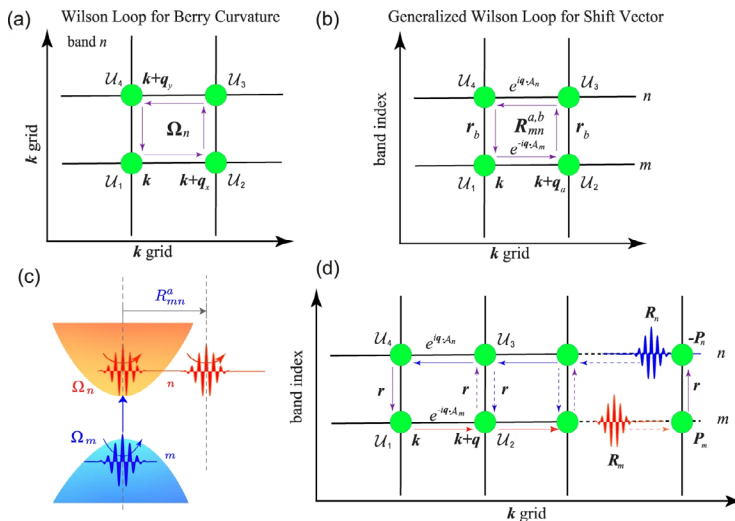


AROUND THE INSTITUTE

JU LI, NSE MSE

“Generalized Wilson loop method for nonlinear light-matter interaction”

Hua Wang, Xiuyu Tang, Haowei Xu, Ju Li, Xiaofeng Qian
[npj Quantum Materials \(2022\)](#) | [arXiv:2206.04560 \(2022\)](#)



a Berry curvature $\Omega_z(k)\Omega_z(k)$ represented by the overlap matrix elements between Bloch wavefunctions UU at neighboring k -points. The Wilson loop is $W_n(k) = \langle U_1|U_2\rangle\langle U_2|U_3\rangle\langle U_3|U_4\rangle\langle U_4|U_1\rangle$. $W_n(k) = \langle U_1|U_2\rangle\langle U_2|U_3\rangle\langle U_3|U_4\rangle\langle U_4|U_1\rangle$. b Shift vector $R_{mn}(k)$ represented by Bloch wavefunctions UU at neighboring k -points and transition matrix elements $rmnr_{mn}$. The Wilson loop for shift vector $W_{mn}(k) = \langle U_1|U_2\rangle\langle U_2|r|U_3\rangle\langle U_3|U_4\rangle\langle U_4|r|U_1\rangle$. $W_{mn}(k) = \langle U_1|U_2\rangle\langle U_2|r|U_3\rangle\langle U_3|U_4\rangle\langle U_4|r|U_1\rangle$ is associated with the interband transition. c, d Physical meaning of shift vector: The integral of the Wilson loops results in the polarization difference between two bands upon optical transition and the relative shift of the charge center of the wave packet involving a pair of states.

“Acid-in-Clay Electrolyte for Wide-Temperature-Range and Long-Cycle Proton Batteries”

Shitong Wang, Heng Jiang, Yanhao Dong, David Clarkson, He Zhu, Charles M Settens, Yang Ren, Thanh Nguyen, Fei Han, Weiwei Fan, So Yeon Kim, Jianan Zhang, Weijiang Xue, Sean K Sandstrom, Guiyin Xu, Emre Tekoglu, Mingda Li, Sili Deng, Qi Liu, Steven G Greenbaum, Xiulei Ji, Tao Gao, Ju Li
[Advanced Materials \(2022\)](#)

“Nanosecond protonic programmable resistors for analog deep learning”

Murat Onen, Nicolas Emond, Baoming Wang, Difei Zhang, Frances M. Ross, Ju Li, Bilge Yildiz, Jesús A. del Alamo
[MIT News \(2022\)](#) | [Science \(2022\)](#)

“Ion-Beam Radiation-Induced Eshelby Transformations: The Mean and Variance in Hydrostatic and Shear Residual Stresses”

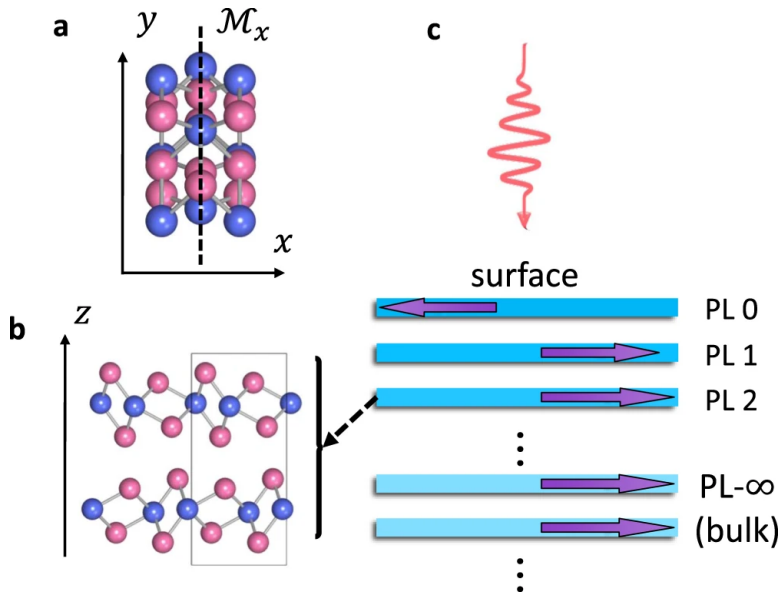
Yongchao Chen, Qing-Jie Li, Alex O'Brien, Yang Yang, Qi He, David A. Bloore, Joost J. Vlassak, Ju Li
[arXiv:2208.04147 \(2022\)](#)

“First-principles Calculation of the Temperature-dependent Transition Energies in Spin Defects”

Hao Tang, Ariel Rebekah Barr, Guoqing Wang, Paola Cappellaro, Ju Li
[arXiv:2205.02791 \(2022\)](#)

**AROUND THE INSTITUTE****JU LI**, NSE MSE**“Abnormal nonlinear optical responses on the surface of topological materials”**

Haowei Xu, Hua Wang, Ju Li

[npj Computational Materials \(2022\)](#) | [arXiv:2109.05592 \(2021\)](#)**MINGDA LI**, NSE**“M-STAR: Magnetism second target advanced reflectometer at the Spallation Neutron Source”**

Valeria Lauter, Kang Wang, Tim Mewes, Artur Glavic, Boris Toperverg, Mahshid Ahmadi, Badih Assaf, Bin Hu, Mingda Li, Xinyu Liu, Yaohua Liu, Jagadeesh Moodera, Leonid Rokhinson, Deepak Singh, Nian Sun

[Review of Scientific Instruments \(2022\)](#)**“Machine learning magnetism classifiers from atomic coordinates”**

Helena A Merker, Harry Heiberger, Linh Nguyen, Tongtong Liu, Zhantao Chen, Nina Andrejevic, Nathan C Drucker, Ryotaro Okabe, Song Eun Kim, Yao Wang, Tess Smidt, Mingda Li

[Iscience \(2022\)](#)**“Challenges and Opportunities of Machine Learning on Neutron and X-ray Scattering”**

Nathan C Drucker, Tongtong Liu, Zhantao Chen, Ryotaro Okabe, Abhijatmedhi Chotrattanapituk, Thanh Nguyen, Yao Wang, Mingda Li

[Synchrotron Radiation News \(2022\)](#)



AROUND THE INSTITUTE

MINGDA LI, NSE

“Machine learning spectral indicators of topology”

N. Andjejevic, J. Andrejevic, C. H. Rycroft and M. Li

[MIT News \(2022\)](#) | [Advanced Materials \(2022\)](#) | [arXiv:2003.00994 \(2022\)](#)



Topological materials are an exotic class of materials whose surfaces can have different electrical or optical properties than their interiors and might someday be used in next generation computer chips or quantum devices.

“High ambipolar mobility in cubic boron arsenide”

Jungwoo Shin, Geethal Amila Gamage, Zhiwei Ding, Ke Chen, Fei Tian, Xin Qian, Jiawei Zhou, Hwijong Lee, Jianshi Zhou, Li Shi, Thanh Nguyen, Fei Han, Mingda Li, David Broido, Aaron Schmidt, Zhifeng Ren, Gang Chen

[Science \(2022\)](#)

“Testing the data framework for an AI algorithm in preparation for high data rate X-ray facilities”

Hongwei Chen, Sathya R. Chitturi, Rajan Plumley, ..., Mingda Li, et. al

[arXiv:2210.10137 \(2022\)](#)

“Witnessing Light-Driven Entanglement using Time-Resolved Resonant Inelastic X-Ray Scattering”

Jordyn Hales, Utkarsh Bajpai, Tongtong Liu, Denitsa R. Baykusheva, Mingda Li, Matteo Mitrano, Yao Wang

[arXiv:2209.02283 \(2022\)](#)

“Self-Eval: Self-supervised Fine-grained Dialogue Evaluation”

Longxuan Ma, Ziyu Zhuang, Weinan Zhang, Mingda Li, Ting Liu

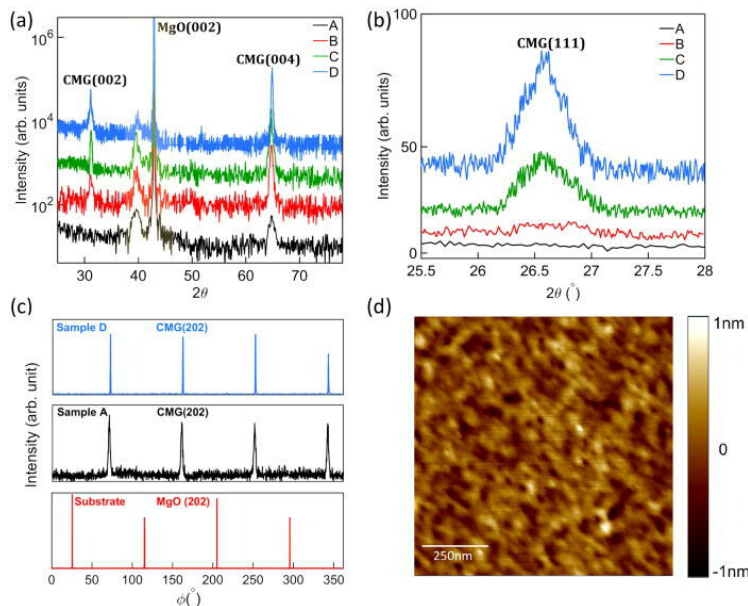
[arXiv:2208.08094 \(2022\)](#)

AROUND THE INSTITUTE

MINGDA LI, NSE

“Demonstration of LogicLib: An Expressive Multi-Language Interface over Scalable Datalog System”Mingda Li, Jin Wang, Guorui Xiao, Youfu Li, Carlo Zaniolo
[arXiv:2205.14857 \(2022\)](#)**“Recent Progress in Conversational AI”**Zijun Xue, Ruirui Li, Mingda Li
[arXiv:2204.09719 \(2022\)](#)

LUQIAO LIU, EECS

“Probing antiferromagnetic coupling in magnetic insulator/metal heterostructures”Patrick Quarterman, Yabin Fan, Zhijie Chen, Christopher J. Jensen, Rajesh V. Chopdekar, Dustin A. Gilbert, Megan E. Holtz, Mark D. Stiles, Julie A. Borchers, Kai Liu, Luqiao Liu, and Alexander J. Grutter
[Phys. Rev. Materials \(2022\)](#)**“Spin-generation in magnetic Weyl semimetal Co₂MnGa across varying degree of chemical order”**Taqiyyah S Safi, Chung-Tao Chou, Justin T Hou, Jiahao Han, Luqiao Liu
[Appl. Phys. Lett. \(2022\)](#)

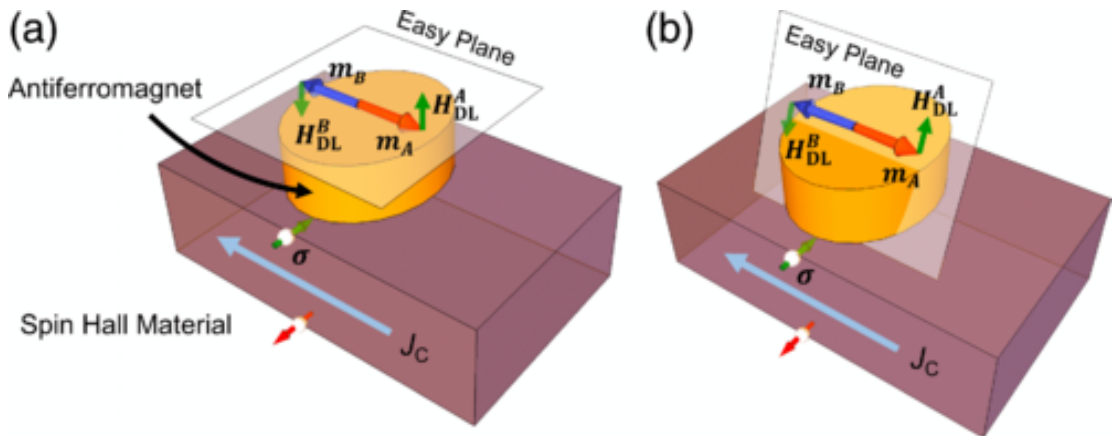
(a) XRD θ - 2θ scans of Co₂MnGa (100 nm) films with T_{dep} = RT, 300, 400, and 600 °C grown on the MgO (001) substrate (the shaded area depicts substrate peaks) and (b) 2θ -scan for the (111) plane and (c) ϕ -scan of (202) planes from Co₂MnGa grown at 600 °C, RT, and the MgO substrate. (d) Atomic force microscopy image of the Co₂MnGa (10 nm)/Pt (3 nm) film. The scale bar is 250 nm.

AROUND THE INSTITUTE

LUQIAO LIU, EECS

“Control of Néel Vector with Spin-Orbit Torques in an Antiferromagnetic Insulator with Tilted Easy Plane”

Pengxiang Zhang, Chung-Tao Chou, Hwanhui Yun, Brooke C. McGoldrick, Justin T. Hou, K. Andre Mkhoyan, and Luqiao Liu
[Phys. Rev. Lett. \(2022\)](#) | [arXiv:2201.04732 \(2022\)](#)



An antiferromagnet with its easy plane parallel with the film surface. Dampinglike torque effective fields $H_{DL}^{A(B)}$ rotate the two magnetic moments $m_{A(B)}$ toward out-of-plane directions. (b) An antiferromagnet with the easy plane forming a finite angle with the film surface. $H_{DL}^{A(B)}$ have components for rotating $m_{A(B)}$ within the easy plane.

SETH LLOYD, ME, ES, Physics

“Quantum computational finance: martingale asset pricing for incomplete markets”

Patrick Reberntrost, Alessandro Luongo, Samuel Bosch, Seth Lloyd
[arXiv:2209.08867 \(2022\)](#)

“Wasserstein Complexity of Quantum Circuits”

Lu Li, Kaifeng Bu, Dax Enshan Koh, Arthur Jaffe, Seth Lloyd
[arXiv:2208.06306 \(2022\)](#)

“Geometric Event-Based Relativistic Quantum Mechanics”

Vittorio Giovannetti, Seth Lloyd, Lorenzo Maccone
[arXiv:2206.08359 \(2022\)](#)

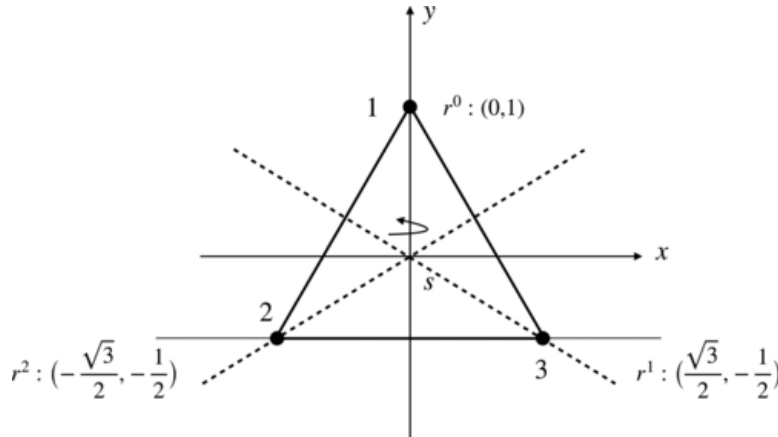
“Complexity-Theoretic Limitations on Quantum Algorithms for Topological Data Analysis”

Authors: Alexander Schmidhuber, Seth Lloyd
[arXiv:2209.14286 \(2022\)](#)

“Quantum algorithms for group convolution, cross-correlation, and equivariant transformations”

Grecia Castelazo, Quynh T. Nguyen, Giacomo De Palma, Dirk Englund, Seth Lloyd, and Bobak T. Kiani

[Phys. Rev. A \(2022\)](#) | [arXiv:2109.11330 \(2021\)](#)



The dihedral group D_3 is the symmetry group of an equilateral triangle; that is, it is the set of all transformations such as reflection, rotation, and combinations of these, that leave the shape and position of this triangle fixed.

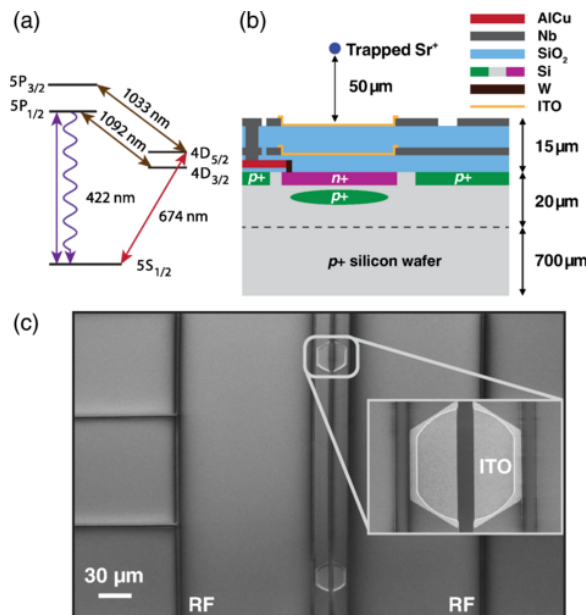


ROBERT MCCONNELL, ME, ES, Physics

“High-Fidelity Ion State Detection Using Trap-Integrated Avalanche Photodiodes”

David Reens, Michael Collins, Joseph Ciampi, Dave Kharas, Brian F. Aull, Kevan Donlon, Colin D. Bruzewicz, Bradley Felton, Jules Stuart, Robert J. Niffenegger, Philip Rich, Danielle Braje, Kevin K. Ryu, John Chiaverini, and Robert McConnell

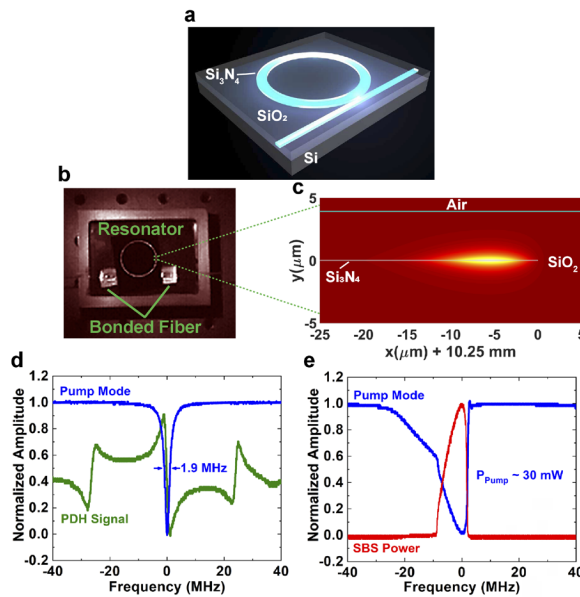
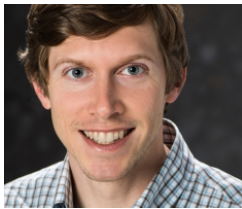
[Phys. Rev. Lett. \(2022\)](#) | [arXiv:2202.01715 \(2022\)](#)



(a) Simplified level structure of the Sr^+ ion.
(b) Cross-sectional illustration of the fabricated SPADs within the ion trap chip (not to scale). (c) SEM image of representative device after fabrication (plan view). SPADs with ITO coating (seen in inset) are located directly underneath ion trapping sites and spaced $240\ \mu\text{m}$ apart. Rf voltage is applied to the two indicated electrodes, while dc voltages are applied to the remaining electrodes to generate an ion-trapping potential as described in the text.

AROUND THE INSTITUTE**ROBERT MCCONNELL**, ME, ES, Physics**“Cooling of an integrated Brillouin laser below the thermal limit”**

William Loh, Dave Kharas, Ryan Maxson, Gavin N. West, Alexander Medeiros, Danielle Braje, Paul W. Juodawlkis, and Robert McConnell

[Optics Express \(2022\)](#) | [arXiv:2112.00846 \(2022\)](#)

SBS annulus resonator and mode profile. a, Illustration of the SBS resonator consisting of a thin layer of Si₃N₄ buried in SiO₂. b, Infrared photograph of the SBS resonator bonded to two fiber couplers. The integrated chip is packaged in a 3 × 2.25 × 1 inch copper enclosure. c, Simulated mode profile of the SBS annulus resonator. Only the peripheral of the 100 μm Si₃N₄ width where the mode is confined is shown. d, Measured lineshape from a pump laser scan over a resonator mode performed at low optical powers. The mode is critically coupled and exhibits a loaded linewidth of 1.9 MHz. The PDH scan with 25 MHz sideband spacing is also superimposed. e, Scan of the pump laser over the resonator mode at high optical powers. The backreflected SBS power is also plotted. The SBS power builds up to a maximum at resonance.

ANAND NATARAJAN, EECS**“Quantum Locally Testable Code with Exotic Parameters”**Andrew Cross, Zhiyang He, Anand Natarajan, Mario Szegedy, Guanyu Zhu
[arXiv:2209.11405 \(2022\)](#)

FARNAZ NIROUI, EECS

“Nanoparticle contact printing with interfacial engineering for deterministic integration into functional structures”

Weikun (Spencer) Zhu, Peter F. Satterthwaite, Patricia Jastrzebska-Perfect, Roberto Brenes, Farnaz Niroui.

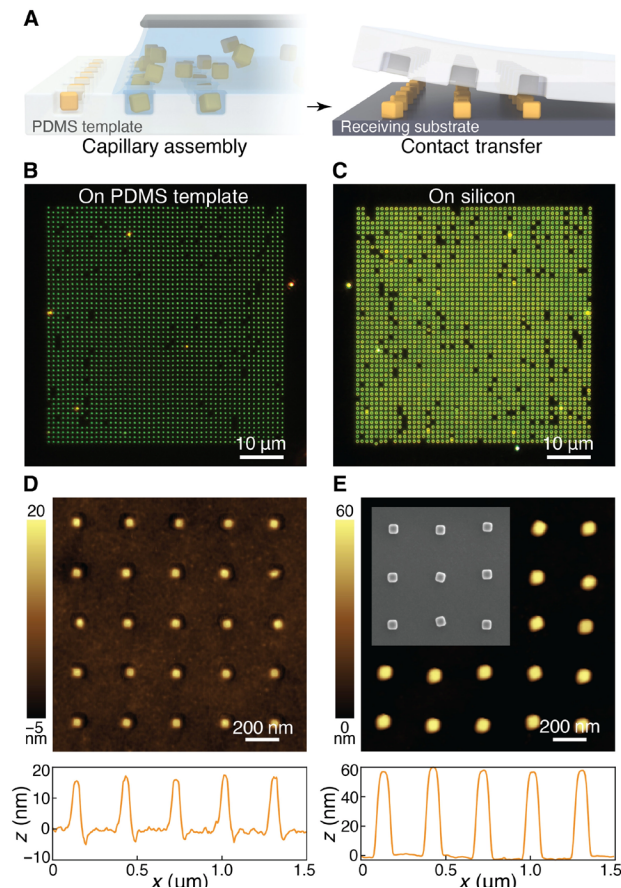
[MIT News](#) | [Science Advances \(2022\)](#)

Fig. 1. Nanoparticle contact printing for precise, scalable, and pristine particle patterning.

(A) Schematic of the printing process: Nanoparticles are positioned onto a PDMS topographical template using capillary assembly, followed by their dry contact transfer onto a receiving substrate. (B) Dark-field image of a representative 50×50 array of ~ 55 -nm gold nanocubes assembled onto a PDMS template. (C) Dark-field image of the same nanocube array after contact transfer onto a silicon substrate. (D) AFM image of gold nanocubes assembled onto PDMS template with the height profile showing particle protrusion above the template surface. (E) AFM image and height profile after transfer onto silicon surface. The inset shows a scanning electron microscope (SEM) image of the corresponding cubes at the same scale.

JELENA NOTAROS, EECS

“Silicon Photonics for LiDAR, Augmented Reality, and Beyond”

Jelena Notaros

[Computational Optical Sensing and Imaging \(2022\)](#)

AROUND THE INSTITUTE

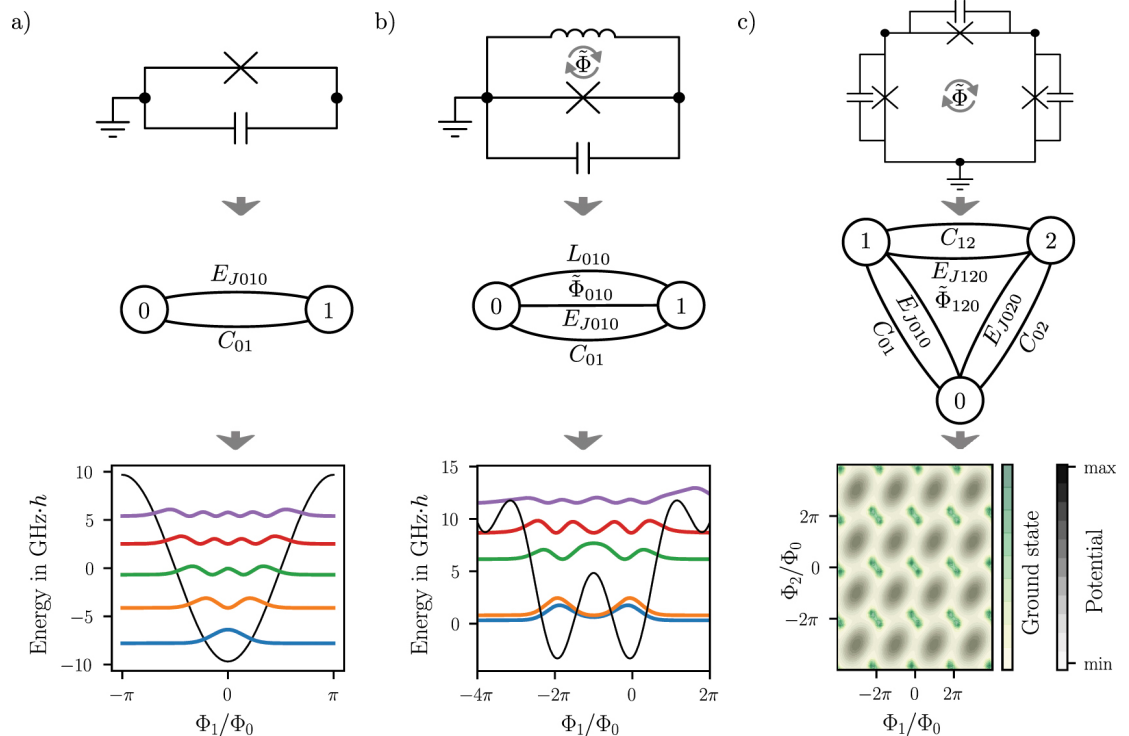
WILLIM D OLIVER, EECS, Physics,
Lincoln Laboratory

with Jeff Grover, RLE; Simon Gustavsson, RLE;
Terry Orlando, EECS; Mollie Schwartz, Lincoln Laboratory;
Joel I-Jan Wang, RLE; Jonilyn Yoder, Lincoln Laboratory

“CircuitQ: An open-source toolbox for superconducting circuits”

P. Aumann, T. Menke, W. D. Oliver, W. Lechner

[New J. Phys. 24 093012 \(2022\)](#) | [arXiv:2106.05342 \(2021\)](#)

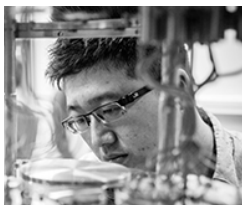
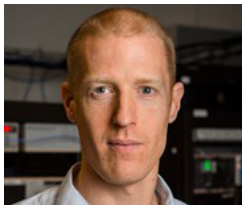


Overview of the functionality of CircuitQ for three example circuits, as discussed in section 4. The general procedure to analyze a superconducting circuit (top row) is to interpret it as a graph whose edges correspond to the circuit elements (middle row). The graph serves as the input of the toolbox, and a symbolic and a numerical Hamiltonian are constructed from it. The potential and eigenspectrum of the Hamiltonian are shown in the bottom row. The symbolic Hamiltonians and parameter values can be found in section 4, and the code to generate these instances is listed in appendix B. (a) Transmon circuit. The last row depicts the scaled absolute value squared of the wavefunctions of the lowest five eigenstates as a function of the flux variable Φ_1 , which is the node flux variable connected to node 1 of the respective graph in the middle row, while the scaling factor Φ_0 is the flux quantum. Each wave function is offset by its corresponding eigenvalues. The potential of the Hamiltonian is shown as a black line. (b) Fluxonium circuit. The scaled wavefunctions of the eigenstates and potential energy are shown in the same fashion as in (a). (c) Persistent-current flux qubit circuit. Due to the additional node, the problem becomes two-dimensional. Similar to before, Φ_1 and Φ_2 are the node variables of node 1 and 2 in the circuit graph. We show an overlap of two contour plots, where one depicts the scaled absolute value squared of the wavefunction of the lowest eigenstate and the other visualizes the potential.

“Nonreciprocal devices based on voltage-tunable junctions”

Catherine Leroux, Adrian Parra-Rodriguez, Ross Shillito, Agustin Di Paolo,
William D. Oliver, Charles M. Marcus, Morten Kjaergaard, András Gyenis,
Alexandre Blais

[arXiv:2209.06194 \(2022\)](#)



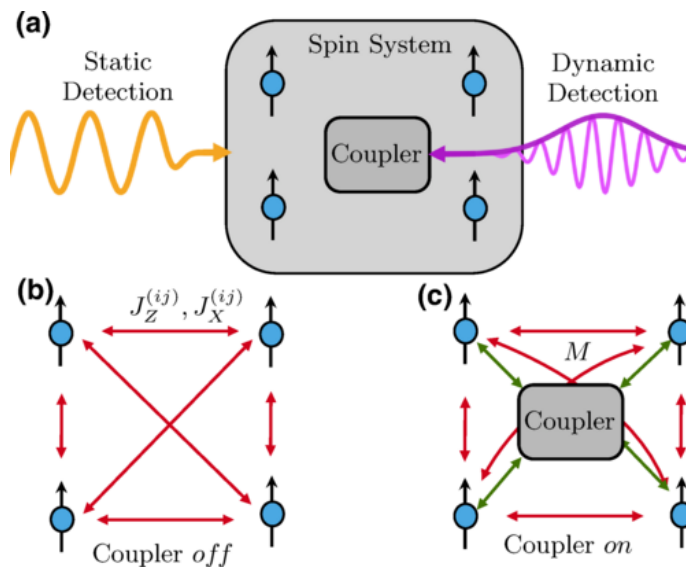
AROUND THE INSTITUTE

WILLIM D OLIVER, EECS, Physics,
Lincoln Laboratory

with Jeff Grover, RLE; Simon Gustavsson, RLE;
Terry Orlando, EECS; Mollie Schwartz, Lincoln Laboratory;
Joel I-Jan Wang, RLE; Jonilyn Yoder, Lincoln Laboratory

“Distinguishing multi-spin interactions from lower-order effects”

Thomas R. Bergamaschi, Tim Menke, William P. Banner, Agustin Di Paolo, Steven J. Weber, Cyrus F. Hirjibehedin, Andrew J. Kerman, and William D. Oliver
[Phys. Rev. Applied 18, 044018 \(2022\)](#) | [arXiv:2111.12717 \(2021\)](#)



A system of artificial spins coupled via a multispin coupler. (a) The types of techniques to detect multispin interactions considered in this work. Static detection techniques probe steady-state behavior with continuous-wave drives, whereas dynamic techniques such as coupler pulses lead to transient behavior. (b) A schematic of the system for $n=4$ when the coupler is off, including pairwise interactions J_Z and J_X between all pairs of spins. (c) When the coupler is turned on, a 4-local term with coupling strength M as well as spurious terms of lower locality are added to the system Hamiltonian.

“Dissipative Landau-Zener tunneling: crossover from weak to strong environment coupling”

X. Dai, R. Trappen, H. Chen, D. Melanson, M. A. Yurtalan, D. M. Tennant, A. J. Martinez, Y. Tang, E. Mozhgunov, J. Gibson, J. A. Grover, S. M. Disseler, J. I. Basham, S. Novikov, R. Das, A. J. Melville, B. M. Niedzielski, C. F. Hirjibehedin, K. Serniak, S. J. Weber, J. L. Yoder, W. D. Oliver, K. M. Zick, D. A. Lidar, A. Lupascu
[arXiv:2207.02017 \(2022\)](#)

“Nonreciprocal devices based on voltage-tunable junctions”

Catherine Leroux, Adrian Parra-Rodriguez, Ross Shillito, Agustin Di Paolo, William D. Oliver, Charles M. Marcus, Morten Kjaergaard, András Gyenis, Alexandre Blais
[arXiv:2209.06194 \(2022\)](#)

“Fast neutron background characterization of the future Ricochet experiment at the ILL research nuclear reactor”

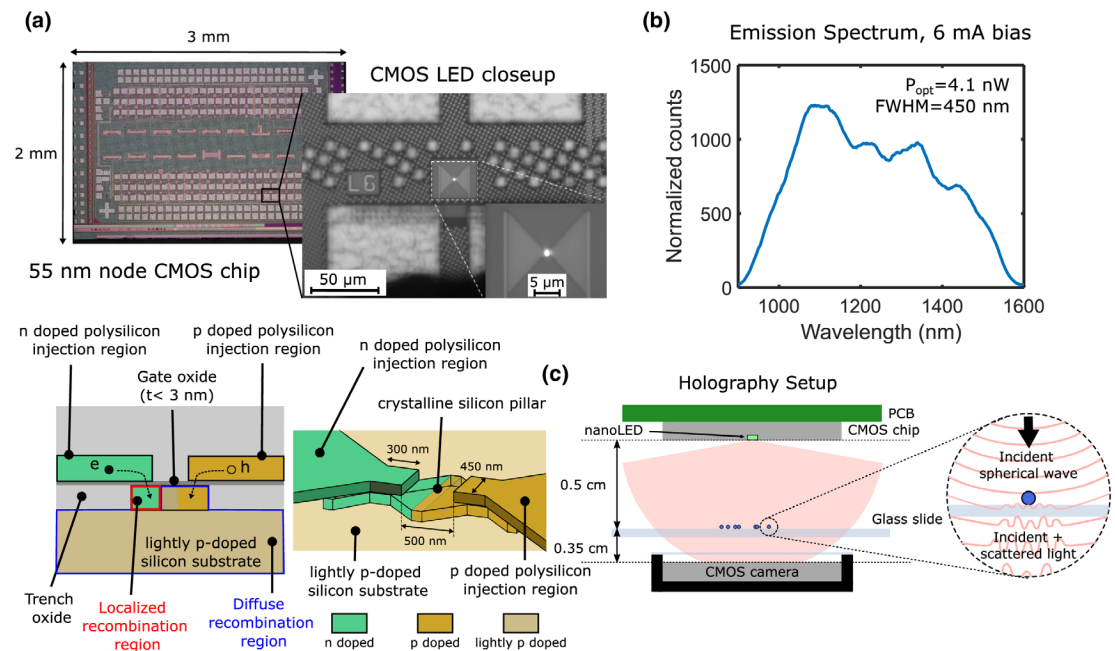
C. Augier, et al.
[arXiv:2208.01760 \(2022\)](#)

AROUND THE INSTITUTE

RAJEEV RAM, EECS

“Simultaneous spectral recovery and CMOS micro-LED holography with an untrained deep neural network”

Iksung Kang, Marc de Cea, Jin Xue, Zheng Li, George Barbastathis, Rajeev J Ram

[Optica \(2022\)](#)

CMOS LED light source and holography apparatus. (a) On the top, a micrograph of the 2mm x 3mm 55nm-bulk CMOS chip is shown, as well as a closeup of the tapered LED source. The inset shows the light emission spot when the LED is forward biased, demonstrating an emission spot below $1.3\mu\text{m} \times 1.3\mu\text{m} \times 1.3\mu\text{m} \times 1.3\mu\text{m}$. On the bottom, a schematic of the LED configuration is shown. 10 μm long tapers in the polysilicon layer are used to inject carriers into a crystalline silicon pillar region via breakdown of the thin gate oxide. Once in the crystalline silicon, phonon-assisted carrier recombination results in light emission. (b) The experimentally measured emission spectrum when the LED source is biased at a current of 6 mA. The spectrum has an FWHM of 450 nm with a peak wavelength around 1100 nm. (c) Schematic of the lensless holography microscope. The light emitted by the CMOS LED illuminates the sample, and the coherent interaction between the light that interacts with the sample and the unscattered light is recorded by a CMOS camera in the form of a hologram. The small emission spot of the CMOS LED eliminates the need for a pinhole, and its large numerical aperture allows for placement of the source very close to the sample, resulting in a compact setup.

“A sub-wavelength Si LED integrated in a CMOS platform”

Zheng Li, Jin Xue, Marc de Cea, Jaehwan Kim, Hao Nong, Daniel Chong, Khee Yong Lim, Elgin Quek, Rajeev Ram

[Research Square \(2022\)](#)**“Native Waveguide Light Emitting Diodes in Silicon Electronic-Photonic Platforms”**

Marc de Cea and Rajeev J. Ram

[CLEO: Science and Innovations \(2022\)](#)

From the Director

CQE PI Feature

CQE Student Feature

● **Around the Institute**

Beyond the Institute

Quantum Conferences

AROUND THE INSTITUTE



KYLE SERNIAC, Lincoln Laboratory

“Distinguishing parity-switching mechanisms in a superconducting qubit”

Spencer Diamond, Valla Fatemi, Max Hays, Kyle Serniak, et. al
[PRX Quantum](#) | [arXiv:2204.07458 \(2022\)](#)

PETER SHOR, Mathematics

“The Early Days of Quantum Computation”

Peter W. Shor
[arXiv:2208.09964 \(2022\)](#)

“Publicly verifiable quantum money from random lattices”

Andrey Boris Khesin, Jonathan Z. Lu, Peter W. Shor
[arXiv:2207.13135 \(2022\)](#)

VIVISHEK SUDHIR, ME

“Ultimate limits and prospects of long-baseline optical fiber interferometry”

C. Hilweg, D. Shadmany, P. Walther, N. Mavalvala, V. Sudhir
[arXiv:2208.09247 \(2022\)](#)

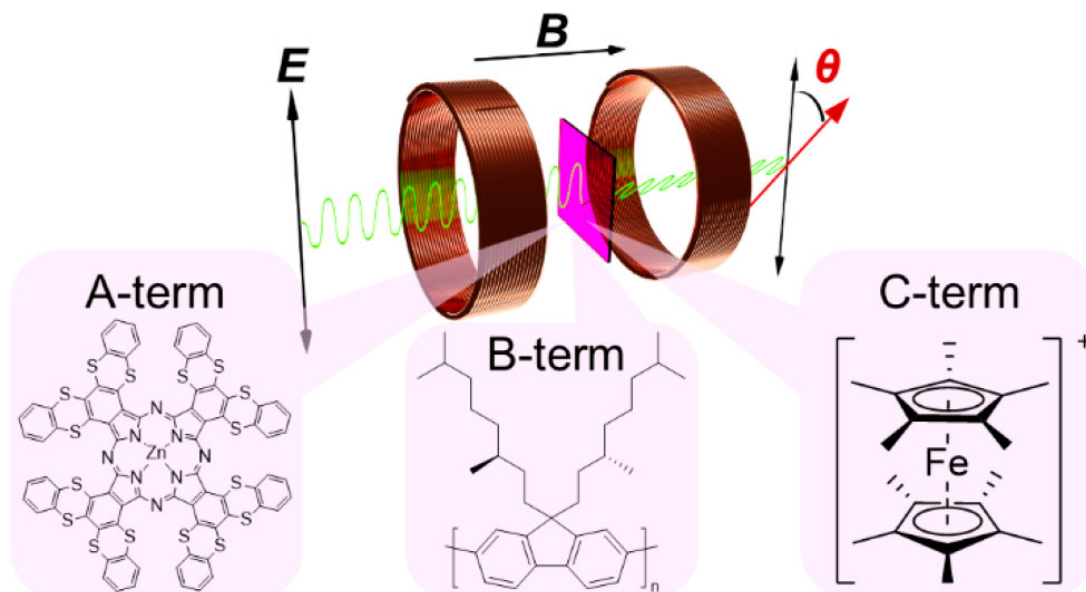
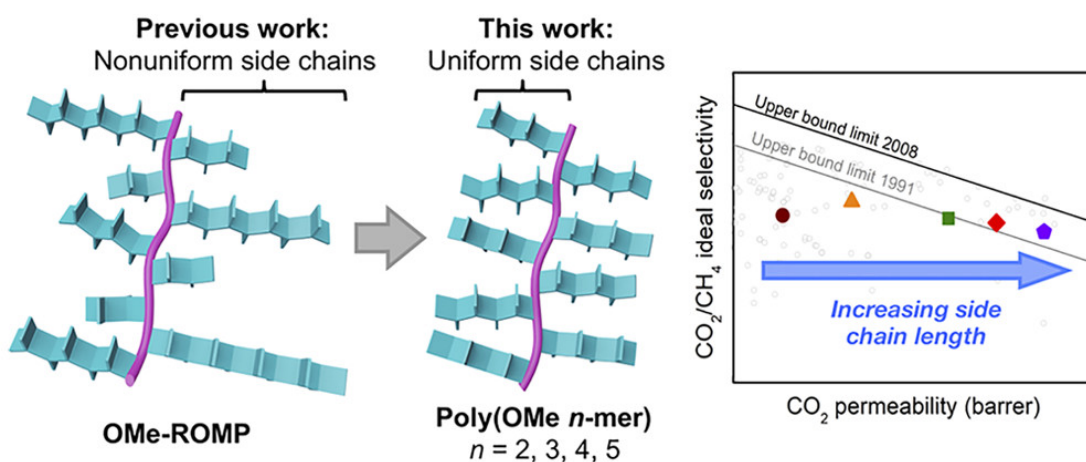
“Theory of phase-adaptive parametric cooling”

A. Ghosh, P. Kumar, F. Jimenez, V. Sudhir, C. Genes
[arXiv:2205.12791 \(2022\)](#)



AROUND THE INSTITUTE

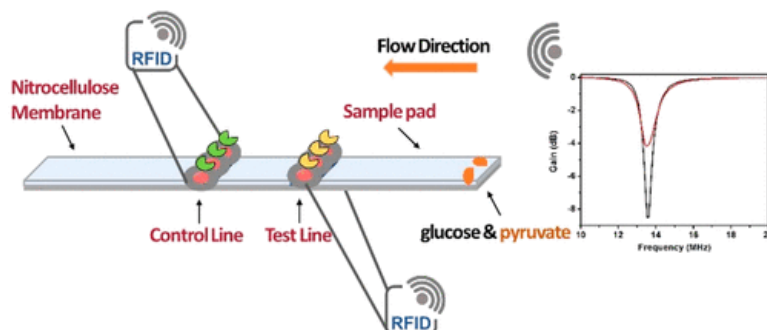
TIMOTHY SWAGER, Chemistry

“ABCs of Faraday Rotation in Organic Materials”Z. Nelson, Delage-Laurin, L., and Swager, T. M.
[J. Am. Chem. Soc., \(2022\)](#)**“Side-Chain Length and Dispersity in ROMP Polymers with Pore-Generating Side Chains for Gas Separations”**F. M. Benedetti, Wu, Y. - C. Mason, Lin, S., He, Y., Flear, E., Storme, K. R., Liu, C., Zhao, Y., Swager, T. M., and Smith, Z. P.
[JACS Au \(2022\)](#)

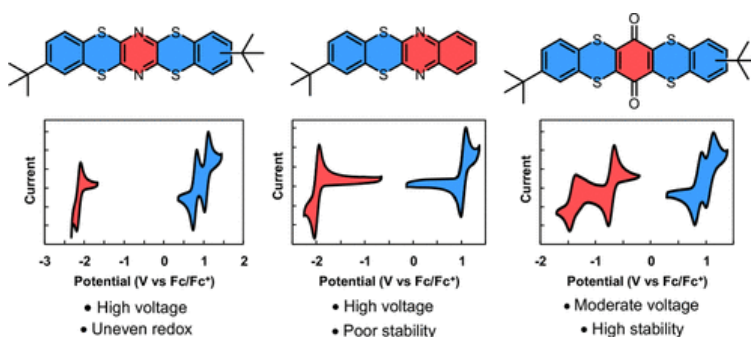


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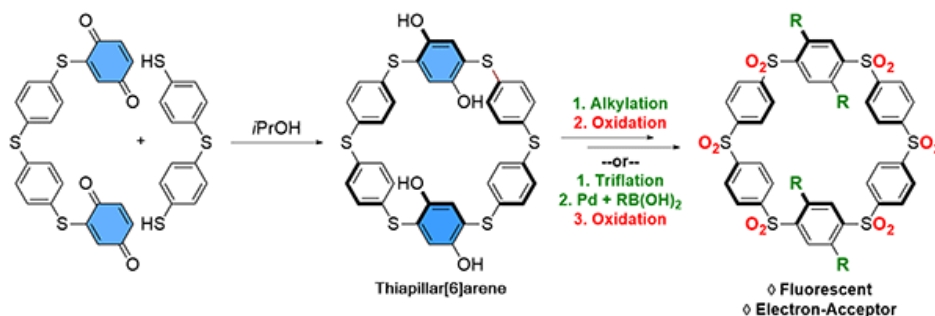
TIMOTHY SWAGER, Chemistry

“Wireless Lateral Flow Device for Biosensing”Li, J, Yuan, W, Luo, S-XLennon, Bezdek, MJ, Peraire-Bueno, A, Swager, TM
[J. Am. Chem. Soc., \(2022\)](#)**“Thianthrene-Based Bipolar Redox-Active Molecules Toward Symmetric All-Organic Batteries”**

Etkind, SI, Lopez, J, Zhu, YGuang, Fang, J-H, Ong, WJie, Shao-Horn, Y, Swager, TM

[ACS Sustainable Chem. Eng. \(2022\)](#)**“Thiapillar[6]arene: Synthesis, Functionalization, and Properties”**

Etkind, SI, Ichii, S, Romero, NA, Swager, TM

[Synlett \(2022\)](#)



AROUND THE INSTITUTE

SENTHIL TODADRI, Physics

“Strong correlations in ABC-stacked trilayer graphene: Moiré is important”

Authors: Adarsh S. Patri, T. Senthil

[arXiv:2210.08025 \(2022\)](#)**“Dipole condensates in tilted Bose-Hubbard chains”**

Ethan Lake, Hyun-Yong Lee, Jung Hoon Han, T. Senthil

[arXiv:2210.02470 \(2022\)](#)**“Loop current fluctuations and quantum critical transport”**

Zhengyan Darius Shi, Dominic V. Else, Hart Goldman, and T. Senthil

[arXiv:2208.04328 \(2022\)](#)**“Metal to Wigner-Mott insulator transition in two-leg ladders”**

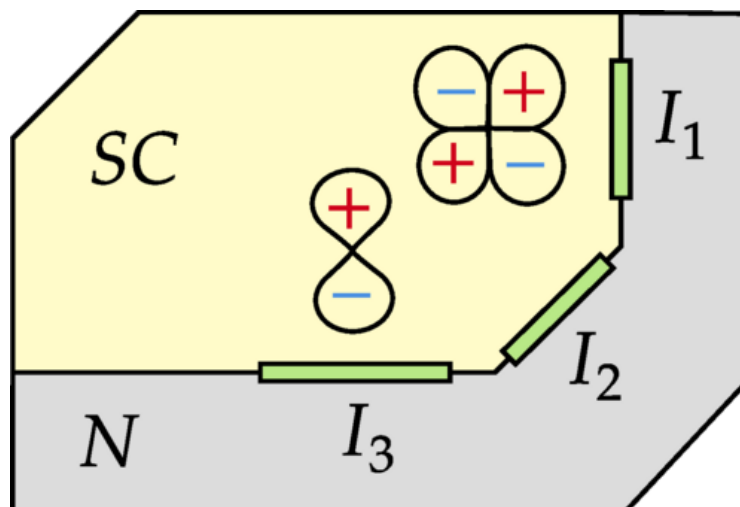
Seth Musser, T. Senthil

[arXiv:2207.07128 \(2022\)](#)**“Translation-enriched Z2 spin liquids and topological vison bands: Possible application to α -RuCl₃”**

Xue-Yang Song, T. Senthil

[arXiv:2206.14197 \(2022\)](#)**“Pairing symmetry of twisted bilayer graphene: a phenomenological synthesis”**

Ethan Lake, Adarsh S. Patri, T. Senthil

[Phys. Rev. B \(2022\)](#) | [arXiv:2204.12579 \(2022\)](#)

A schematic of the Andreev bound state measurement needed to distinguish between p- and d-wave pairing. The grey region marked N is a normal metal, while the green bars I_i ($i=1,2,3$) denote different interfaces at which the zero-bias tunneling conductance $G_{0,i}$ is measured. A comparison of the values of $G_{0,i}$ can distinguish between p-wave pairing (where all of the $G_{0,i}$ are distinct) and d-wave pairing (where $G_{0,1}=G_{0,3}$). For the orientation of the nodes as shown, the d-wave order parameter would exhibit large zero bias peaks at I_1 and I_3 and no peak at I_2 , while the p-wave order parameter would exhibit no peak at I_1 , a medium peak at I_2 , and a large peak at I_3 .

AROUND THE INSTITUTE

TROY VAN VOORHIS, Chemistry

“Exchange controlled triplet fusion in metal–organic frameworks”

Dong-Gwang Ha, Ruomeng Wan, Changhae Andrew Kim, Ting-An Lin, Luming Yang, Troy Van Voorhis, Marc A Baldo, Mircea Dincă.

[Nature Materials \(2022\)](#)

“Machine Learning Identification of Active Sites in Graphite-Conjugated Catalysts”

Kunal Lodaya, Nathan Ricke, Kelly Chen, Troy Van Voorhis

[chemRxiv \(2022\)](#)

“Words Matter: On the Debate over Free Speech, Inclusivity, and Academic Excellence”

John M. Herbert, Martin Head-Gordon, Hrant P. Hratchian, Teresa Head-Gordon, Rommie E. Amaro, Alán Aspuru-Guzik, Roald Hoffmann, Carol A. Parish, Christina M. Payne, and Troy Van Voorhis

[J. Phys. Chem. Lett. \(2022\)](#)



VLADAN VULETIĆ, Physics

“Control and Entanglement of Individual Rydberg Atoms Near a Nanoscale Device”

Paloma L Ocola, Ivana Dimitrova, Brandon Grinkemeyer, Elmer Guardado-Sanchez, Tamara Dordevic, Polnop Samutpraphoot, Vladan Vuletic, Mikhail D Lukin

[arXiv:2210.12879 \(2022\)](#)

“Entanglement-Enhanced Optical Atomic Clocks”

Simone Colombo, Edwin Pedrozo-Peñafiel, Vladan Vuletić

[arXiv:2209.00471 \(2022\)](#)

“Principles of tractor atom interferometry”

Georg A Raithel, Alisher Duspayev, Bineet Dash, Sebastian C Carrasco, Michael H Goerz, Vladan Vuletic, Vladimir S Malinovsky

[Quantum Science and Technology \(2022\)](#) | [arXiv:2207.09023 \(2022\)](#)

“High finesse bow-tie cavity for strong atom-photon coupling in Rydberg arrays”

Y.-T. Chen, M. Szurak, Y.-C. Yeh, B. Hu, J. de Hond, B. Braverman, and V. Vuletić,

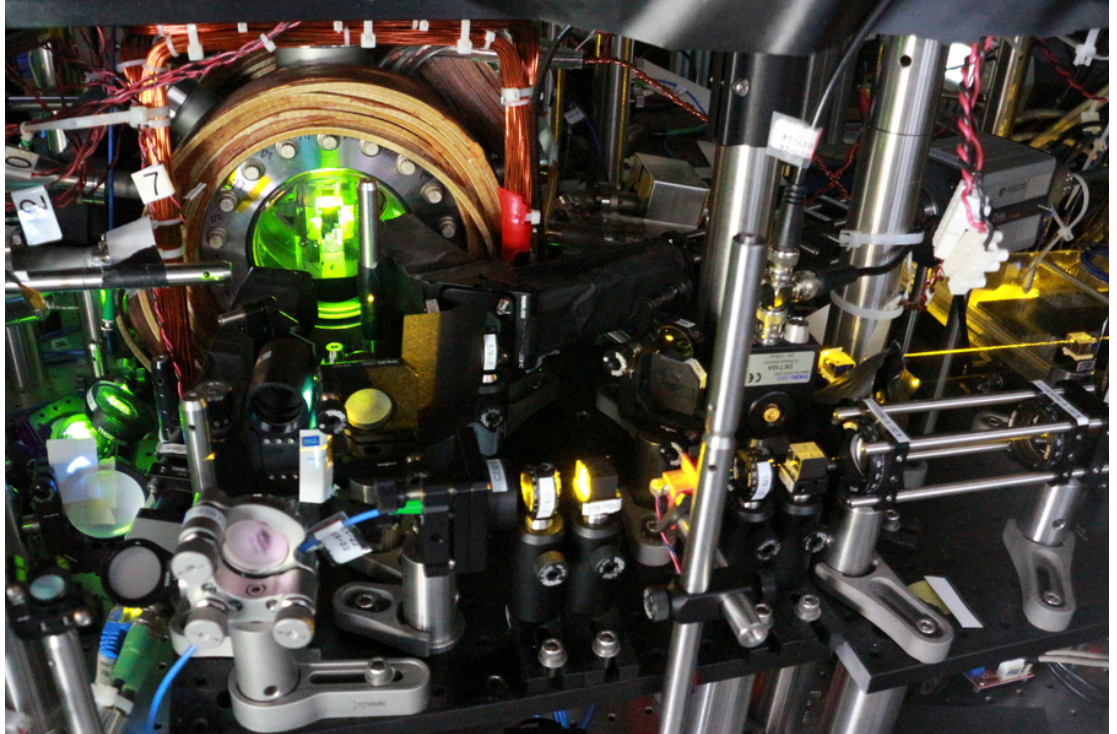
[Optics Express \(2022\)](#) | [arXiv:2207.06876 \(2022\)](#)

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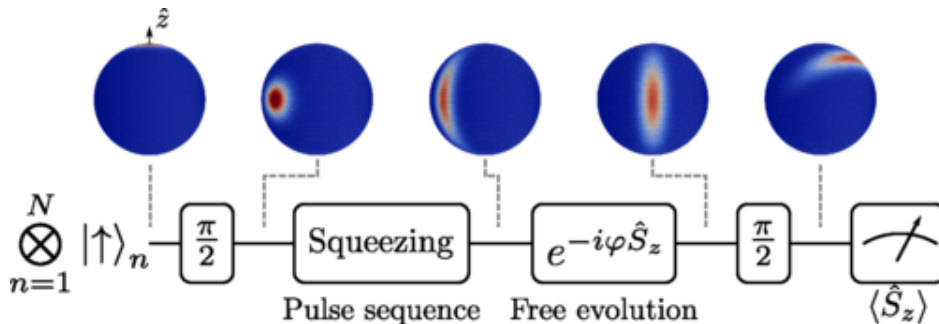
VLADAN VULETIĆ, Physics

“Time-reversal-based quantum metrology with many-body entangled states”

S. Colombo, E. Pedrozo-Penafiel, A. Adiyatullin, Z. Li, E. Mendez, C. Shu, and V. Vuletić

[MIT News](#) | [Nature Physics \(2022\)](#) | [arXiv:2106.03754 \(2021\)](#)

MIT Researchers used a system of lasers to first entangle, then reverse the evolution of a cloud of ultracold atoms.

“Extreme Spin Squeezing via Optimized One-Axis Twisting and Rotations”S.C. Carrasco, M.H. Goerz, Z. Li, S. Colombo, V. Vuletić, and V.S. Malinovsky
[Phys. Rev. Applied \(2022\)](#)A schematic of the modified Ramsey interferometry scheme using spin squeezing. The spheres show the Husimi-Q function $Q(\theta, \phi) = |\langle \Psi | \theta, \phi \rangle|^2$ over the generalized Bloch sphere, where $|\theta, \phi\rangle$ corresponds to a CSS oriented to the direction (θ, ϕ) and $|\Psi\rangle$ is the state after each step in the scheme.

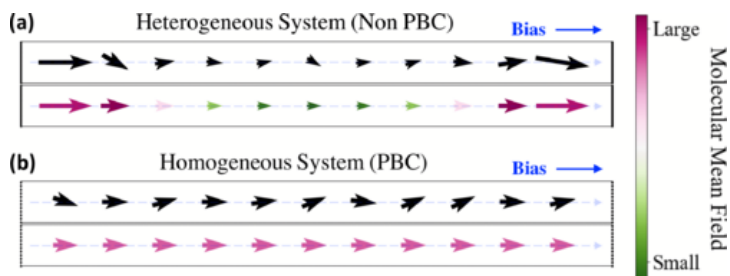


AROUND THE INSTITUTE

ADAM WILLARD, Chemistry

Directed walk in probability space that locates mean field solutions to spin models

Yizhi Shen and Adam P. Willard

[Phys. Rev. E \(2022\)](#)

A schematic contrast of mean field theory applied to homogeneous and heterogeneous systems. Each panel contains a one-dimensional array of dipoles subject to a uniform field biasing the spins to the right, where the top section (black arrows) and bottom section (colored arrows) depict a typical equilibrium configuration and the mean field solution, respectively. Panel (a) shows a spatially heterogeneous

system with open boundary conditions, and panel (b) shows a spatially homogeneous system with periodic boundary conditions (PBCs). Spatial heterogeneity leads to larger dipolar response at the system boundaries, an illustration of dipolar screening.

Persistent Enhancement of Exciton Diffusivity in CsPbBr₃ Nanocrystal Solids

Wenbi Shcherbakov-Wu, Seryio Saris, Thomas Sheehan, Narumi Nagaya Wong, Eric R Powers, Franziska Krieg, Maksym V Kovalenko, Adam P Willard, William A Tisdale

[arXiv:2209.14412 \(2022\)](#)**A directed walk in probability space that locates mean field solutions to spin models**

Yizhi Shen, Adam P Willard

[arXiv:2206.03616 \(2022\)](#)

LINDLEY WINSLOW, Physics

“Snowmass 2021 Cross Frontier Report: Dark Matter Complementarity (Extended Version)”

Antonio Boveia, ..., Lindley Winslow, et.al

[arXiv:2210.01770 \(2022\)](#)**“Report of the Topical Group on Wave Dark Matter for Snowmass 2021”**

Joerg Jaeckel, Gray Rybka, Lindley Winslow

[arXiv:2209.08125 \(2022\)](#)



AROUND THE INSTITUTE

LINDLEY WINSLOW, Physics

“Latest Results from the CUORE Experiment”

I. Nutini, ..., L. Winslow, et al. (CUORE Collaboration)
[Journal of Low Temperature Physics \(2022\)](#)

“Optimization of the first CUPID detector module”

CUPID Collaboration, ..., L. Winslow, et. al
[The European Physical Journal C \(2022\)](#)

“The Double Chooz antineutrino detectors”

H. de Kerret, ..., L. Winslow, et. al
[The European Physical Journal C \(2022\)](#)

“Abundances of Uranium and Thorium Elements in Earth Estimated by Geoneutrino Spectroscopy”

S. Abe, ..., L. Winslow, et. al
[Geophysical Research Letters \(2022\)](#)

“Fast neutron background characterization of the future Ricochet experiment at the ILL research nuclear reactor”

C Augier, ..., L. Winslow, et. al
[arXiv:2208.01760 \(2022\)](#)

“New measurement of double beta decays of ^{100}Mo to excited states of ^{100}Ru with the CUPID-Mo experiment”

CUPID-Mo Collaboration: C. Augier, ..., L. Winslow, et. al
[arXiv:2207.09577 \(2022\)](#)

“Determining gA/gV with High Resolution Spectral Measurements Using an Li-InSe2 Bolometer”

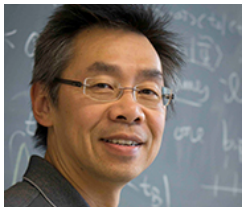
AF Leder, D Mayer, JL Ouellet, FA Danevich, L Dumoulin, A Giuliani, J Kostensalo, P de Marcillac, C Nones, V Novati, E Olivieri, D Poda, J Suhonen, VI Tretyak, L Winslow, A Zolotarova
[arXiv:2206.06559 \(2022\)](#)

“An Energy-dependent Electro-thermal Response Model of CUORE Cryogenic Calorimeter”

CUORE Collaboration: D. Q. Adams, ..., L. Winslow, et. al
[arXiv:2205.04549 \(2022\)](#)

AROUND THE INSTITUTE

FRANCO N. C. WONG, RLE

“Spectral control of nonclassical light pulses using an integrated thin-film lithium niobate modulator”Di Zhu, ..., Franco N.C. Wong, et. al
[Research Square \(2022\)](#)

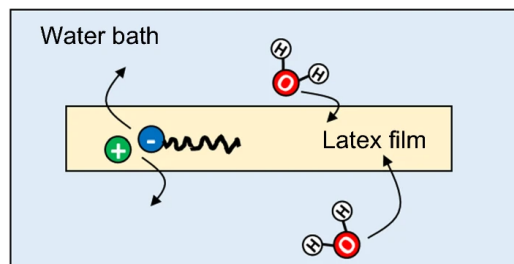
BILGE YILDIZ, NSE MSE

“Electrochemical Ionic Synapses: Progress and Perspectives”

Mantao Huang, Miranda Schwacke, Murat Onen, Jesús del Alamo, Ju Li, Bilge Yildiz

[Advanced Materials \(2022\)](#)**“Coupled effect of water absorption and ion transport in hydrated latex anti-corrosion coatings”**

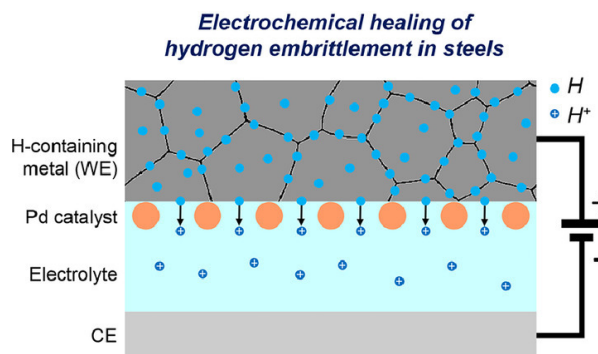
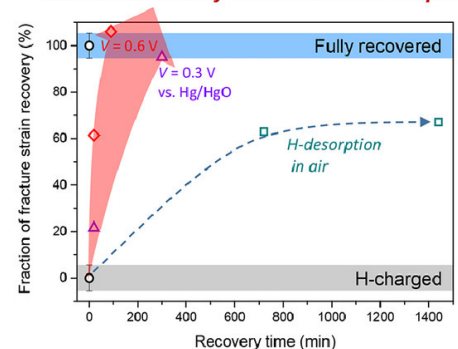
Yu Ren Zhou, Surya Effendy, Juner Zhu, Michael T Petr, Colin D Cwalina, Martin Z Bazant, Bilge Yildiz, Ju Li, Michael P Short

[J. Coat. Technol. Res. \(2022\)](#)

A schematic representation of water absorption and ion transport in hydrated latex films which are measured in this study. Transport of the types of ionic surfactants used for emulsion polymerization³⁴ within formed latex films near room temperature has been observed in previous studies^{35, 36}

“Electrochemical pumping: An alternative solution for hydrogen embrittlement”

Jinwoo Kim, Xiahui Yao, Decheng Kong, Ju Li, Bilge Yildiz, C. Cem Tasan

[Appl. Mater. Today \(2022\)](#)**Accelerated healing by electrochemically stimulated H-desorption**



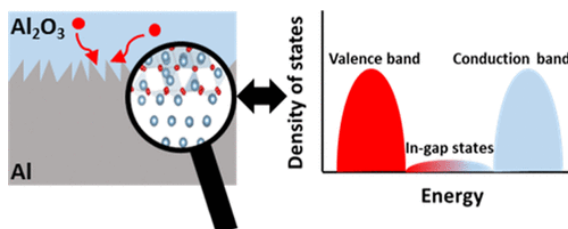
AROUND THE INSTITUTE

BILGE YILDIZ, NSE MSE

“Atomic and Electronic Structure of the Al₂O₃/Al Interface during Oxide Propagation Probed by Ab Initio Grand Canonical Monte Carlo”

Vrindaa Somjit, Bilge Yildiz

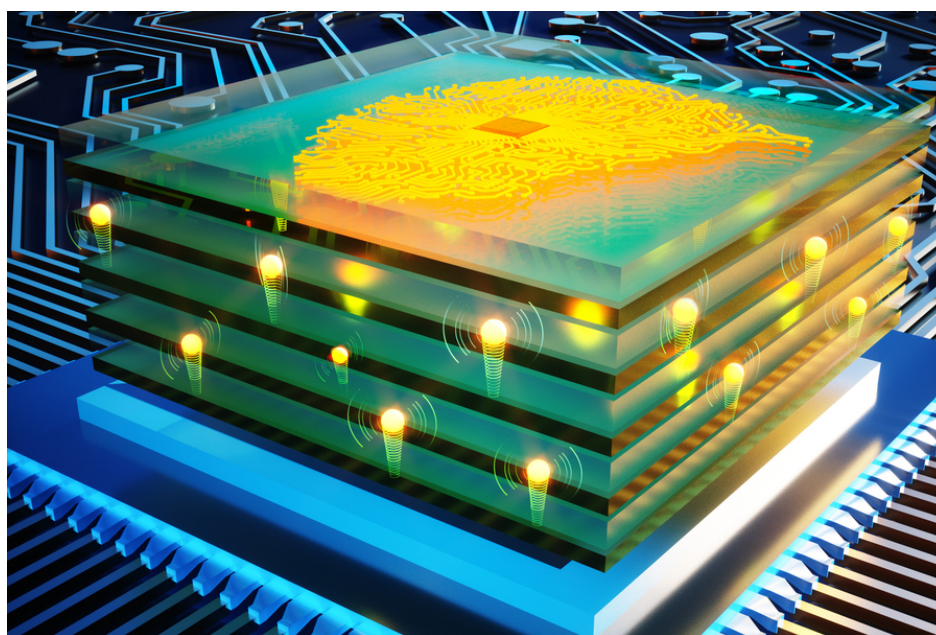
[ACS Appl. Mater. Interfaces \(2022\)](#)



“Nanosecond protonic programmable resistors for analog deep learning”

Murat Onen, Nicolas Emond, Baoming Wang, Difei Zhang, Frances M. Ross, Ju Li, Bilge Yildiz, Jesús A. del Alamo

[MIT News \(2022\)](#) | [Science \(2022\)](#)



This illustration shows an analog deep learning processor powered by ultra-fast protonics.

“Bulk and Surface Exsolution Produce a Variety of Fe-Rich and Fe-Depleted Ellipsoidal Nanostructures in Functional Perovskite Thin Films”

Komal Syed, Jiayue Wang, Bilge Yildiz, William J Bowman

[Microscopy and Microanalysis. 2542-2542 \(2022\)](#)

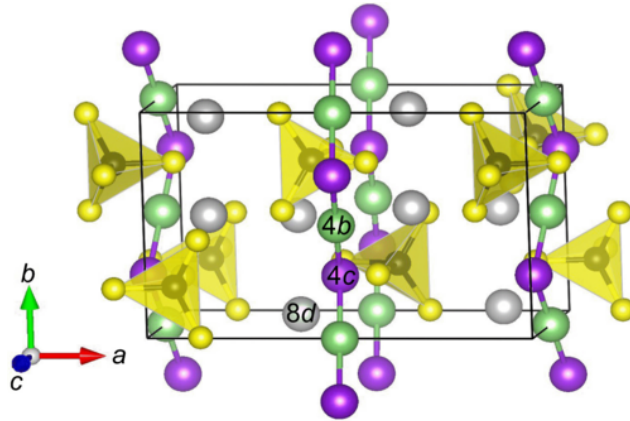


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BILGE YILDIZ, NSE MSE

“Strain Sensitivity of Li-ion Conductivity in β -Li₃PS₄ Solid Electrolyte”

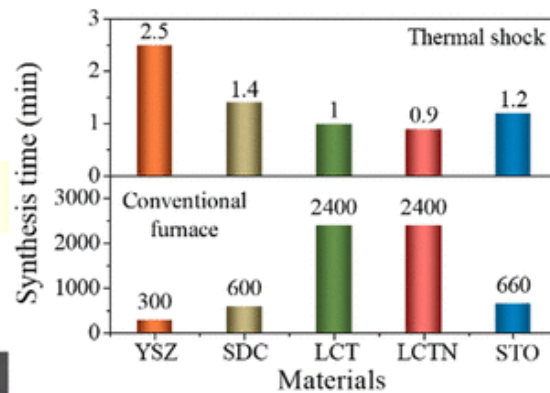
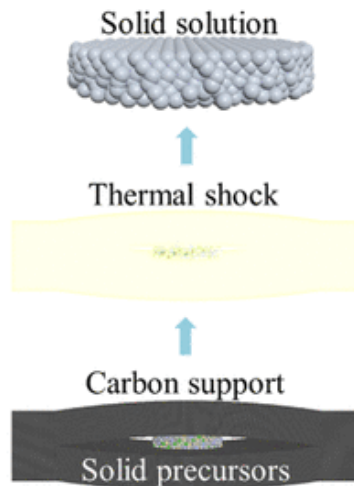
Pjotr Žgurs, Bilge Yildiz

[PRX Energy. 023003 \(2022\)](#)

β -Li₃PS₄ orthonorhombic unit cell (Pnma space group, oP32 [64]). PS₄ tetrahedra are shown in yellow (P is black at the center of the tetrahedron). Li sites: 8d, gray; 4b, green; 4c, violet. Conventional cell shown in this figure contains 4 formula units (4Li₃PS₄), with 12 Li ions distributed over a total of 16 sites (8d, 4b, 4c). 8d and 4b sites are almost fully occupied and the 4c site is almost empty [63]. Li-ion diffusion is especially fast along the facile 4b-4c chain, but other pathways also contribute to overall transport (8d-4c, 8d-4b and 8d-8d) [63]. In this and further figures, we use vesta software for visualization of crystal structures [65].

“Synthesizing Functional Ceramic Powders for Solid Oxide Cells in Minutes through Thermal Shock”

Weiwei Fan, Zhichu Ren, Zhu Sun, Xiahui Yao, Bilge Yildiz, Ju Li

[ACS Energy Lett. \(2022\)](#)

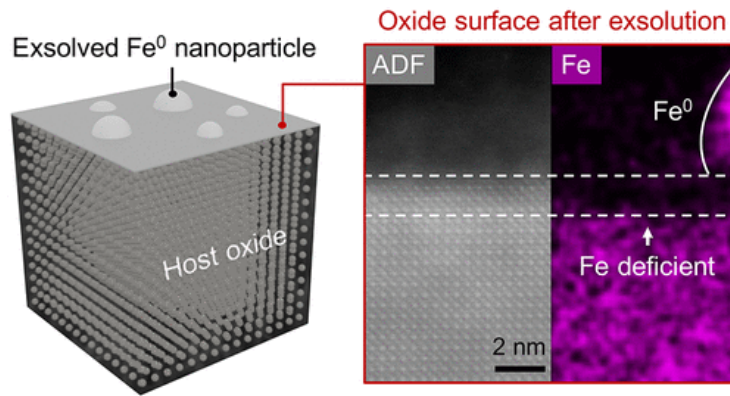
AROUND THE INSTITUTE

BILGE YILDIZ, NSE MSE

“Exsolution-Driven Surface Transformation in the Host Oxide”

Jiayue Wang, Abinash Kumar, Jenna L Wardini, Zhan Zhang, Hua Zhou, Ethan J Crumlin, Jerzy T Sadowski, Kevin B Woller, William J Bowman, James M LeBeau, Bilge Yildiz

[Nano Lett. \(2022\)](#)



MARTIN ZWIERLEIN, Physics

“Direct observation of non-local fermion pairing in an attractive Fermi-Hubbard gas”

Thomas Hartke, Botond Oreg, Carter Turnbaugh, Ningyuan Jia, Martin Zwierlein
[arXiv:2208.05948 \(2022\)](#)

Publications

[Suppressing quantum errors by scaling a surface code logical qubit](#)

R. Acharya et. al., including MIT-CQE member, E. Farhi [[arXiv](#)]

[Noise-resilient Majorana Edge Modes on a Chain of Superconducting Qubits](#)

X. Mi, et. al., including MIT-CQE member, E. Farhi [[arxiv](#)]

[Direct measurement of nonlocal interactions in the many-body localized phase](#)

B. Chiaro, et. al., including MIT-CQE member, E. Farhi [[Phys. Rev. Research](#)]

[Time-crystalline eigenstate order on a quantum processor](#)

X. Mi, et. al., including MIT-CQE member, E. Farhi [[Nature](#)]

[The QAOA gets stuck starting from a good classical string](#)

M Cain, et. al., including MIT-CQE member, E Farhi [[arXiv](#)]

[The Quantum Approximate Optimization Algorithm and the Sherrington-Kirkpatrick Model at Infinite Size](#)

MIT-CQE member, E. Farhi, et. al. [[Quantum J](#)]

[Formation of robust bound states of interacting photons](#)

A Morvan, et. al., including MIT-CQE member, E Farhi [[arXiv](#)]

[Fourteen Entangled Photons Expel a Quantum Computing Bottleneck](#)

According to Philip Thomas, a doctoral student at the Max Planck Institute of Quantum Optics, to the best of the scientists' knowledge, the 14 interconnected light particles are the largest number of entangled photons that have been generated in a laboratory. [[Nature](#)]

[Quantum AI breakthrough: theorem shrinks appetite for training data](#)

Many people believe that quantum machine learning will require a lot of data. We have rigorously shown that for many relevant problems, this is not the case," said Lukasz Cincio, a quantum theorist at Los Alamos National Laboratory. [[Nature Comm.](#)]

[Researchers Demonstrate Error Correction in a Silicon Qubit System](#)

Here we demonstrate a three-qubit phase-correcting code in silicon, in which an encoded three-qubit state is protected against any phase-flip error on one of the three qubits. [[Nature](#)]

[‘Levitating’ nanoparticles could push the limits of quantum entanglement](#)

The ‘levitating’ nanoparticles have now been manipulated with enough precision to open new ways of probing the enigmatic twilight zone between the everyday world and the counter-intuitive quantum physics that governs objects at the atomic scale. [[Nature](#)]

BEYOND THE INSTITUTE**[A Faster Way to Study 2D Materials for Next-Generation Quantum and Electronic Devices](#)**

By combining STM measurements with machine learning tools, the new approach cut the imaging time down to about 8 hours. “From about three weeks down to a third of a day,” Thomas said. “It’s a good leap forward.” [[npj Computational Materials](#)]

[Seeing electron movement at fastest speed ever could help unlock next-level quantum computing](#)

The first, a pulse of infrared light, puts the electrons into a state that allows them to travel through the material. The second, a lower-energy terahertz pulse, then forces those electrons into controlled head-on collision trajectories. The crashes produce bursts of light, the precise timing of which reveals interactions behind quantum information and exotic quantum materials alike. [[Nature](#)]

[Boron Nitride with a Twist Could Lead to New Way to Make Qubits](#)

A team led by researchers from the Department of Energy’s Lawrence Berkeley National Laboratory (Berkeley Lab) has now developed a method, using a solid-state “twisted” crystalline layered material, which gives rise to tiny light-emitting points called color centers. These color centers can be switched on and off with the simple application of an external voltage. [[Nature Materials](#)]

[Milestones achieved on the path to useful quantum technologies](#)

“Our system allows entangled states of increasing size to be gradually built up -- which is much more reliable, faster, and more efficient than any previous method. For us, this represents a milestone that puts us in striking distance of practical applications of large, entangled states for useful quantum technologies.” [[Phys. Rev. Lett.](#)]

[University of Illinois Researchers Close a Gap in the Quantum Cloning Machine Literature](#)

In their article “Process-optimized phase-covariant quantum cloning,” Kim and Chitambar note that there is a missing detail in the discussion of cloning machines specialized to so-called phase covariant states (a type of quantum state easy to characterize and manipulate) that contain multiple levels. [[Phys. Rev. A](#)]

[A new method to enable efficient interactions between photons](#)

The researchers used the efficient and coherent coupling of a single quantum emitter with a nanophotonic waveguide to enable nonlinear quantum interactions between single-photon wave packets. To do this, they used a single quantum dot, a nm-sized particle that behaves like a two-level atom, which was embedded in a photonic crystal waveguide. [[Nature Communications](#)]

BEYOND THE INSTITUTE**Quantum computing engineers set new standard in silicon chip performance**

“Think of it like two kids on a swing who are pretty much going forward and backwards in sync,” says Ms Seedhouse. “If we give one of them a push, we can get them reaching the end of their arc at opposite ends, so one can be a 0 when the other is now a 1.” [[Applied Physics Reviews](#)]

Artificial intelligence reduces a 100,000-equation quantum physics problem to only four equations

“We start with this huge object of all these coupled-together differential equations; then we’re using machine learning to turn it into something so small you can count it on your fingers,” says study lead author Domenico Di Sante. [[Phys. Rev. Lett.](#)]

Universal control of a six-qubit quantum processor in silicon

We design, fabricate and operate a six-qubit processor with a focus on careful Hamiltonian engineering, on a high level of abstraction to program the quantum circuits, and on efficient background calibration, all of which are essential to achieve high fidelities on this extended system. [[Nature](#)]

‘Twisty’ photons could turbocharge next-gen quantum communication

“Normally the spin angular momentum and the orbital angular momentum are independent properties of a photon. Our device is the first to demonstrate simultaneous control of both properties via the controlled coupling between the two,” explained Yichen Ma. [[Optica](#)]

**Key element for a scalable quantum computer**

They succeeded in transferring electrons, the carriers of quantum information, over several micrometres on a quantum chip. Their “quantum bus” could be the key component to master the leap to millions of qubits. [[npj quantum information](#)]

D-Wave Demonstrates Large-Scale Coherent Quantum Annealing

This demonstration goes beyond the scale of any previous programmable quantum phase transition, opening the door to simulations of exotic phases of matter that would otherwise be intractable. [[nature physics](#)]

Geometric quantum adiabatic methods for quantum chemistry

We propose a quantum algorithm based on adiabatic evolution to obtain molecular eigenstates and eigenenergies in quantum chemistry, which exploits a smooth geometric deformation by continuously varying bond lengths and bond angles. [[Phys. Rev. Research](#)]

New Material Magnons: See Spins in a 2D Magnet

Research shows that spinning quasiparticles, or magnons, light up when paired with a light-emitting quasiparticle, or exciton, with potential quantum information applications. [[Nature](#)]

[Measurement-based estimator scheme for continuous quantum error correction](#)

We show that by constructing a measurement-based estimator (MBE) of the logical qubit to be protected, which is driven by the noisy continuous measurement currents of the stabilizers, it is possible to accurately track the errors occurring on the physical qubits in real time. [[Phys. Rev. Research](#)]

[The magneto-optic modulator](#)

The mechanism uses a magnetic field to convert data from electrical current to pulses of light. The light can then travel via fiber-optic cables, which can transmit more information than regular electrical cables while minimizing the heat that leaks into the cryogenic system. [[Nature Electronics](#)]

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Politics and Funding

Quantum in the CHIPS and Science Act of 2022

The Act authorizes activities that (if appropriated) will accelerate the discovery of quantum applications, grow the quantum workforce, and enable cutting-edge R&D through new infrastructure: Quantum User Expansion for Science and Technology Program, Quantum Networking and Communications Research and Standardization, and Next Generation Quantum Leaders Pilot Program.

NATO Exploring Quantum Technology for Future Challenges

NATO has identified quantum as a key emerging technology whose potential applications might enable Allies to extend their warfighting capabilities. The implications of quantum technologies for defence are extensive and include important applications in the fields of computing, communication, and sensing.

Selection of six sites to host the first European quantum computers

The European High Performance Computing Joint Undertaking (EuroHPC JU) has selected six sites across the European Union (EU) to host and operate the first EuroHPC quantum computers: Czechia, Germany, Spain, France, Italy, and Poland.

Quantum science pathway opens up but diversity bedevils workforce plans

The Government has commissioned an urgent report to drive Australia's National Quantum Strategy but it acknowledges that it will be hamstrung if it can't succeed with its STEM workforce diversity plans.

NATO Science for Peace and Security Program Projects Examine Security-related Applications of Quantum Tech

The application of these quantum technologies in the security and defense sectors could help to future-proof the transmission of information, protecting it from increasingly advanced hacking systems and contributing to NATO's efforts to maintain its technological edge.

National Quantum Advisory Committee to Strengthen Australia's Quantum Industry

The committee is made up of leaders from business, science, technology and government. They have expertise across research and development, commercialization, investment, supply chains and national security.

Department of Energy announces \$15 million in exploratory research for extreme-scale science

The projects will address disruptive technology changes from emerging trends in high-end computing, massive datasets, artificial intelligence, and increasingly heterogeneous architectures such as neuromorphic and quantum computing systems.

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[Policy adviser says workforce gains from federal quantum center efforts still a year or more away](#)

Speaking to ATARC members Wednesday, Corey Stambaugh said it will take one or two more years to move talent through the pipeline given the five NQISRCs were only established in the past two years.

[Korea opens quantum tech cooperation center in Washington for joint projects with US](#)

The ministry held an opening ceremony of the Korea-US Quantum Technology Cooperation Center in Washington on Wednesday (U.S. time), attended by some 30 Korean and U.S. officials and experts in the field of quantum studies.

[New Biden Executive Order Aims to Set Focus of Future CFIUS National Security Reviews](#)

The EO directs CFIUS to consider the following criteria: The effect of the transaction on supply chain resilience and security, The effect of the transaction on U.S. technological leadership, Industry investment trends, Cybersecurity risks, and Risks to the protection or integrity of data.

[A Legal View of New NIST Quantum-Resistant Algorithms](#)

“Standard of Care” is legalese for the minimum an organization must do to have acted “reasonably” in a lawsuit. In most data breach cases, if you are found not to have acted reasonably, e.g., by not employing sufficiently strong encryption, you likely will have to pay economic damages.

[Who Are NIST’s Post-Quantum Algorithm Winners?](#)

In July, after a six-year effort, it made monumental progress in the journey to quantum-safe computing systems. NIST announced its winning selections for post-quantum encryption algorithms.

[NIST and Google to Create New Supply of Chips for Researchers and Tech Startups](#)

The NIST/Google collaboration will make available a bottom-layer chip with specialized structures for measuring and testing the performance of the components placed on top of it, including new kinds of memory devices, nanosensors, bioelectronics and advanced devices needed for artificial intelligence and quantum computing.

[Targeting Russia’s Senior Officials, Defense Industrial Base, Financial Infrastructure Leaders, and Human Rights Abusers](#)

OFAC also is issuing a determination prohibiting U.S. persons, wherever located, from providing quantum computing services to any person located in Russia.

[Implementation of Additional Sanctions Against Russia and Belarus Under the Export Administration Regulations \(EAR\) and Refinements to Existing Controls](#)

Quantum computing and advanced manufacturing: This paragraph (g) identifies additional equipment and other items that are believed to not be manufactured in Russia or are otherwise important to Russia in developing advanced production and development capabilities.

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[Research Infrastructure Initiatives in the CHIPS and Science Act](#)

The new CHIPS and Science Act outlines an ambitious vision for research infrastructure, encompassing large-scale science facility construction projects as well as initiatives in areas such as quantum computing, high-intensity lasers, and research reactors.

[NSA Releases Future Quantum-Resistant \(QR\) Algorithm Requirements for National Security Systems](#)

NSS owners and operators should not deploy QR algorithms on mission networks until they have been vetted by NIST and National Information Assurance Partnership (NIAP) as required in CNSSP-11.

[Singapore and Finland Partner to Boost Quantum Tech](#)

The first quantum computer in Finland, Helmi, is housed at VTT, the technical research centre of Finland Ltd., a state-owned and controlled non-profit limited liability business with 30 years of research expertise in developing and commercializing quantum technology solutions.

[Finland and Singapore's National Quantum Office sign memorandum of understanding on quantum research](#)

The National Quantum Office of Singapore, VTT Technical Research Centre of Finland, IQM Quantum Computers, and CSC - IT Center for Science (Finland) agree to explore and promote research and development collaboration in the areas of quantum technologies.

[Greece to Set Up Quantum Computing and Genomics Institutes](#)

The first institute will be based at the National Centre of Scientific Research "Demokritos" in Athens, and the second will be located at the Foundation for Research and Technology (Forth) on Crete.

[China in Past Decade: Leaps and Bounds of Quantum Science Innovations](#)

China successfully sent the world's first micro-nano quantum satellite into space in July 2022, which started the establishment of an efficient, practical and global quantum communications network. The satellite has completed in-orbit tests and will conduct scientific experiments soon.

[EU quantum companies need more investment](#)

As the McKinsey data highlights, in terms of investment in quantum technology start-ups, Europe lags with \$294 million invested from 2001 - 2021, while the US leads the way with \$2.164 billion, the UK is second at \$979 million, and Canada third at \$658 million.

[Quantum computing startups unite to drive Australia's push to be a global leader in the space](#)

Australia's local quantum technology leaders have united with some of the biggest names in global tech to form new industry group for the sector.

Pronouncements and Commentary

[Public-Private Partnerships in Quantum Computing](#)

This report focuses on the near-term. It evaluates potential near-term QC applications as well as the prospect of using public-private partnerships (PPPs) to accelerate the time horizon for meaningful applications of quantum computing.

[Why Quantum Computing Is Even More Dangerous Than Artificial Intelligence](#)

The world's failure to rein in the demon of AI—or rather, the crude technologies masquerading as such—should serve to be a profound warning. There is an even more powerful emerging technology with the potential to wreak havoc.

[CERN joins with leaders from research and industry to propose an Open Quantum Institute](#)

This institute will work to ensure that emerging quantum technologies are put to use to tackle key societal challenges. The proposal is being made through GESDA, the Geneva Science and Diplomacy Anticipator Foundation, in collaboration with leading research institutes and technology companies.

[AWS Takes the Short and Long View of Quantum Computing](#)

Noting that there's "not much evidence" that NISQ era systems will provide decisive business value soon, Severini emphasized quantum computing is a long-term bet.

[Intel's Road to a Universal Quantum Computer Is Via Chiplets](#)

The chipmaker was able to produce stable quantum dots in its existing factories, which is a milestone in the company's long-term goal to build a universal quantum computer. The company used a testing device called a "cryoprobe" to isolate and investigate the uniformity of quantum dots on its wafer.

[Intel Hits Key Milestone in Quantum Chip Production Research](#)

The Intel Labs and Components Research organizations have demonstrated the industry's highest reported yield and uniformity to date of silicon spin qubit devices developed at Intel's transistor research and development facility, Gordon Moore Park at Ronler Acres in Hillsboro, Oregon.

[Intel Labs Quantum and Neuromorphic Computing working to create real world applications](#)

The goal of the Quantum SDK in its beta release is to advance the science behind Quantum computing, create new instances of software that can use the quantum process, and eventually create devices that use quantum computing software.

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[Rigetti Readies Ankaa and Lyra Quantum Processors for 2023, Says Quantum Advantage Close](#)

The upcoming 84-qubit Ankaa system is expected to debut early next year, followed by the 336-qubit Lyra system later in the year. The company announced it is collaborating with Nvidia to develop a hybrid GPU-QPU workflow for climate and weather modeling applications.

[Mastercard launches quantum computer-proof contactless card](#)

The enhanced contactless card uses standards recently revealed by finance industry technical body EMVCo known as “the EMV Contactless Kernel Specifications” that work with all existing payment terminals while also providing higher levels of security that are also “future proof”.

[Quantum computing moves a step closer to solving our most complex problems](#)

The mechanism, known as Quantum Many-Body Scarring (QMBS), is said to be a key step towards potential applications in quantum sensing and metrology, where more qubits can work together to boost the accuracy of measurements, including magnetic and electric fields.



[New neutral-atom qubit offers advantages for quantum computing](#)

The rich internal structure of the “alkali earth-like” metal Yb offers numerous possibilities for cooling and trapping while also making it possible to create qubit systems that are robust to external perturbations. Yb-based qubits could therefore allow for more efficient gate operations, boosting the performance of quantum information processors.

[AT&T Aims to be ‘Quantum Ready’ by 2025](#)

The tier-one operator has been identifying its cryptographic assets, vetting post-quantum cryptography solutions, and taking trials to identify those solutions, according to Brian Miles, principal member of tech staff at AT&T.

[Quantinuum Sets New Record with Highest Ever Quantum Volume](#)

New arbitrary angle gate capabilities enable increase in Quantum Volume (QV) to 8192 as Quantinuum continues to achieve its previously stated objective of increasing its QV by 10x every year.

[Atom Computing to invest \\$100 mln in Colorado for quantum computer center](#)

Atom Computing uses lasers to control individual atoms and build qubits, the basic unit of quantum information. The company has raised a total of \$80 million so far, it said.

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[IonQ signs quantum computing deal with US Air Force](#)

“Trapped ion systems and their performance demonstrated by high algorithmic qubits (AQ) have some very unique properties making them one of the leading technologies in the development of quantum computing and networking capabilities,” said Michael Hayduk, Deputy Director of the Information Directorate at the Air Force Research Lab.

[Quantum Computing Inc. Launches Subscription Service](#)

Customers now have web-based access to Dirac 1, the same EQC that QCI used during the public Quantum Computing for Automotive Challenges event organized by the BMW Group in July.

[How JPMorgan Chase and other banks plan to use quantum computing](#)

In a survey of financial institution leaders West conducted in 2021, 25% said they are currently investing in quantum computing technology and 43% said they planned to invest in 2022.

[Meta-ethics of quantum technologies](#)

Being the foremost practical application of quantum science, the lessons learnt from the use of the atom bomb can indeed be a stepping stone in evolving the ethics of quantum technologies of the 21st century. At the kernel of this learning is to know whether nation-states develop technologies for conflict or cooperation.



[Harvard and AWS launch alliance to advance research in quantum science](#)

The initiative focuses on driving rapid progress toward specific research aims in quantum networking at the Harvard Quantum Initiative (HQI).

[Will Probabilistic Computing Overshadow Quantum Computing](#)

Depending on their spin, the electrons can cause changes or fluctuations within the magnets. These fluctuations are called p-bits—an alternative to the binary on/off or 0/1 bits in classical computers—which may form the basis of probabilistic computing.

[The quantum talent shortage: What can startups learn from the AI sector?](#)

While talent shortages are still a big challenge in the AI sector, startups have found ways of making the hires they need and the industry continues to grow.

QUANTUM CONFERENCES

2022:

5–8 Dec: [Quantum resources: from mathematical foundations to operational characterisation](#)

6–8 Dec: [Q2B22 Silicon Valley](#)

7–10 Dec: [Conference on Quantum Non-Markovianity](#)

14–15 Dec: [Workshop on continuous-variable photonic quantum computing](#)

2023:

8–11 Jan: [Coping with Errors in Scalable Quantum Computing Systems](#)

9–11 Jan: [Jonathan P. Dowling Memorial Conference on Quantum Science and Technology](#)

17–19 Jan: [Qubits](#)

21–27 Jan: [Photonic Quantum Information Processing](#)

28 Jan–2 Feb: [SPIE Quantum Applications: Current and Future](#)

4–10 Feb: [Quantum Information Processing](#) (QIP 2023), Ghent, Belgium

5–10 Feb: [Aspen Winter Conference Quantum Simulation with Quantum Hardware](#)

5–10 Mar: [APS March Meeting](#), Las Vegas

12–17 Mar: [Aspen Winter Conference Novel Quantum States of Matter in Moire Materials](#)

11 Apr–5 May: [Quantum Computing Methods for High Energy Physics](#), Munich, Germany

24–27 Apr: [SPIE Optics + Optoelectronics](#)

21–25 May: [ISC High Performance](#)

23–25 May: [Quantum Matter International Conference](#)

28 May–1 Jun: [IEEE International Conference on Communications](#)

22–23 Jul: [Emerging Physical Platforms and Applications of Quantum Sensors](#)