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7. PERFORMING ORGANIZATION NAMES AND ADDRESSES Gordon Research Conferences, Inc. 512 Liberty Lane West Kingston, RI 02892 -1502	8. PERFORMING ORGANIZATION REPORT NUMBER
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14. ABSTRACT

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16. SECURITY CLASSIFICATION OF:	17. LIMITATION OF ABSTRACT	15. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON Cindy Regal
a. REPORT UU	b. ABSTRACT UU	c. THIS PAGE UU	19b. TELEPHONE NUMBER 303-492-5956

RPPR Final Report

as of 23-May-2023

Agency Code: 21XD

Proposal Number: 80207PECF

Agreement Number: W911NF-22-1-0054

INVESTIGATOR(S):

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Report Date: 07-Jan-2023

Date Received: 19-Dec-2022

Final Report for Period Beginning 08-Apr-2022 and Ending 07-Oct-2022

Title: 2022 Mechanical Systems in the Quantum Regime GRC & GRS

Begin Performance Period: 08-Apr-2022

End Performance Period: 07-Oct-2022

Report Term: 0-Other

Submitted By: Jose D'Incao

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Distribution Statement: 1-Approved for public release; distribution is unlimited.

STEM Degrees:

STEM Participants:

Major Goals: Organizing a Gordon Research Conference involves extensive communication with the research community to identify important issues at the frontiers of the field, and solicit suggestions for speakers and discussion leaders to participate in the conference. The Chair then contacts prospective participants to invite them to talk and discuss the nature of their contributions. The Chair then communicates the topics and aims of the conference through web pages, contact with relevant international professional bodies and email to members of the research community around the world to encourage applications for participation in the conference. The Chair is then responsible for assessing and accepting the applications and fielding a host of questions both concerning the technical content and practical aspects of conference participation.

Accomplishments: The quantum behavior of mechanical excitations across many orders of magnitude in length and mass scales has become an exciting branch of quantum science. Today, researchers are formulating experiments that will harness mechanical excitations and phonons in an increasing range of precision measurements, quantum devices, and tests of fundamental physics. This meeting brought together scientists to discuss the latest experimental and theoretical work on mechanical systems in the quantum regime through lectures and poster sessions. Scientists from a diverse set of fields presented advances in using mesoscopic mechanical devices for quantum information processing and transduction, continuum optomechanics, and fundamental tests with phonons; and elucidate connections to large-scale optical and atomic interferometers and associated fundamental physical measurements.

The Gordon Research Seminar (GRS) on Mechanical Systems in the Quantum Regime is a unique forum for graduate students, post-docs, and other scientists with comparable levels of experience to present new data and cutting-edge ideas, as well as to engage in scientific exchange. The GRS offers the opportunity to present work not only in the form of posters, but also in the form of oral presentations. In this protected "off-the-record" environment, participants are encouraged to freely discuss on-going projects and unpublished data, as well as to develop new collaborations and inspire scientific creativity.

The ability of quantum optomechanical systems to interface mechanical and optical subsystems has granted them an important role in quantum technology. Optomechanical and electromechanical systems have emerged as promising platforms for quantum control of mechanical oscillators, demonstrating, for instance, directly verifiable

RPPR Final Report as of 23-May-2023

preparation of highly non-classical mechanical states in a macro-scale system, and remote quantum entanglement between two mechanical oscillators. Thus, optomechanical and electromechanical systems are promising candidates for building scalable quantum networks, and achieving powerful quantum-enhanced metrology. In addition to the well-established optomechanical workhorses, novel platforms have emerged, e.g. vibrational and rotational optomechanics of levitated objects, magnomechanics, quantum acoustics, and hybrid spin-mechanical systems. Now, optomechanical platforms enable novel tests of fundamental physics, such as matter-wave interferometry with macroscopic objects, the search for physics beyond the standard model, or deviations from Newtonian gravity at sub-micrometer length scales. This seminar covered recent achievements and future prospects, both theoretically and experimentally, for using mechanical quantum systems to develop new technologies and provide novel tests of fundamental physics.

Training Opportunities: Speakers, discussion leaders, poster presenters and attendees simultaneously contributed to and benefited from the collective skills and experience shared throughout the conference.

Results Dissemination: The final program has been posted on the GRC website.

Honors and Awards: Nothing to Report

Protocol Activity Status:

Technology Transfer: Nothing to Report

Partners

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I certify that the information in the report is complete and accurate:

Signature: Darlene Armstrong

Signature Date: 12/19/22 12:25PM



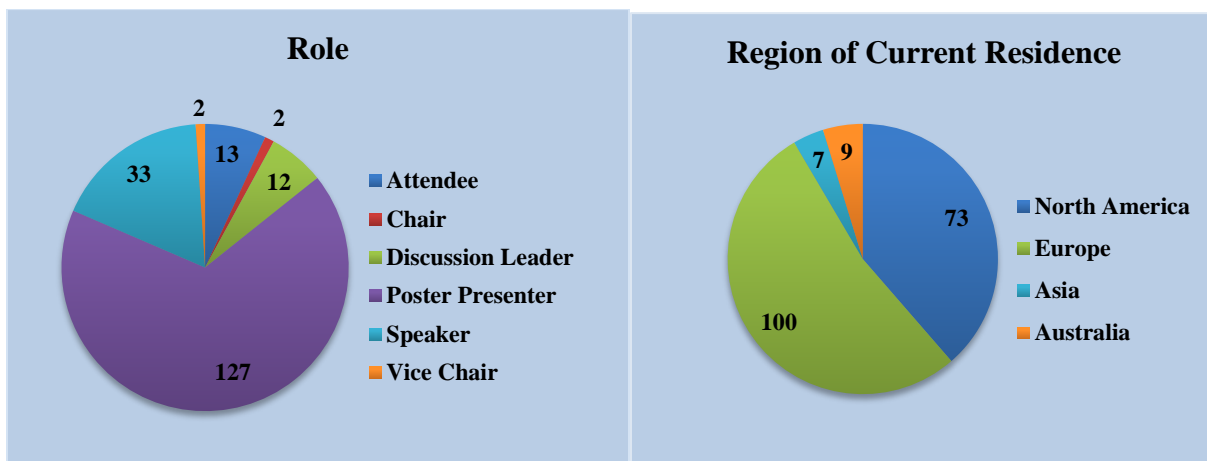
GORDON RESEARCH CONFERENCES
FINAL REPORT
Army Research Office
Mechanical Systems in the Quantum Regime GRC/GRS
Grant Number W911NF2210054

Operational Summary

The Gordon Research Conference (GRC) and Gordon Research Seminar (GRS) on Mechanical Systems in the Quantum Regime were held at the Ventura Beach Marriott in Ventura, California from June 18-24, 2022. The meeting covered a variety of scientific topics and the content presented was highly rated by participants.

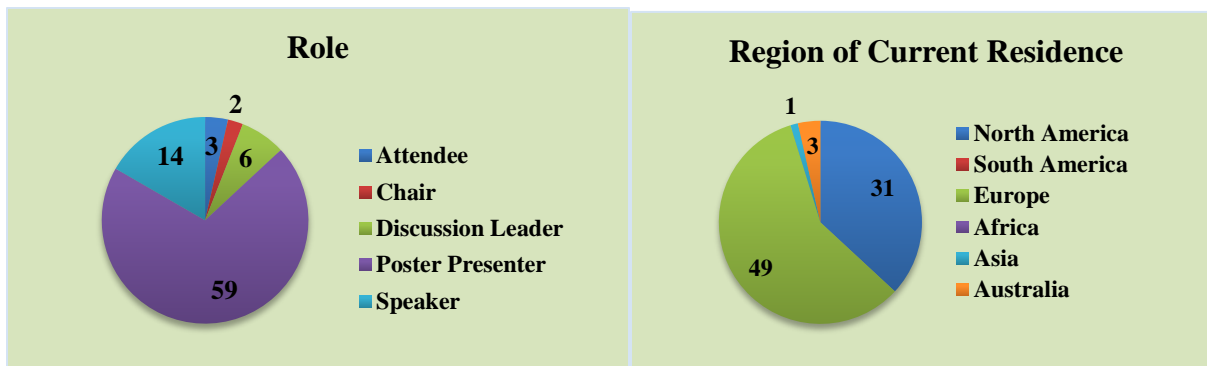
 **Conference Participants**

The Conference was well-attended with 189 participants. Scientists from academia represented 97% of the participants while attendees from government accounted for 3%. The meeting also attracted a strong mix of young investigators and senior scientists. Students and post-docs accounted for 66% of all attendees. Approximately 17% of the participants at the 2022 meeting were women.



Seminar Participants

The Seminar was well-attended with 84 participants. Students and post docs combined accounted for 96% of all attendees. Approximately 20% of the participants at the 2022 seminar were women.



Conference Program

The quantum behavior of mechanical excitations across many orders of magnitude in length and mass scales has become an exciting branch of quantum science. Today, researchers are formulating experiments that will harness mechanical excitations and phonons in an increasing range of precision measurements, quantum devices, and tests of fundamental physics. This meeting brought together scientists to discuss the latest experimental and theoretical work on mechanical systems in the quantum regime through lectures and poster sessions. Scientists from a diverse set of fields presented advances in using mesoscopic mechanical devices for quantum information processing and

transduction, continuum optomechanics, and fundamental tests with phonons; and elucidate connections to large-scale optical and atomic interferometers and associated fundamental physical measurements.

The Gordon Research Seminar (GRS) on Mechanical Systems in the Quantum Regime is a unique forum for graduate students, post-docs, and other scientists with comparable levels of experience to present new data and cutting-edge ideas, as well as to engage in scientific exchange. The GRS offers the opportunity to present work not only in the form of posters, but also in the form of oral presentations. In this protected "off-the-record" environment, participants are encouraged to freely discuss on-going projects and unpublished data, as well as to develop new collaborations and inspire scientific creativity.

The ability of quantum optomechanical systems to interface mechanical and optical subsystems has granted them an important role in quantum technology. Optomechanical and electromechanical systems have emerged as promising platforms for quantum control of mechanical oscillators, demonstrating, for instance, directly verifiable preparation of highly non-classical mechanical states in a macro-scale system, and remote quantum entanglement between two mechanical oscillators. Thus, optomechanical and electromechanical systems are promising candidates for building scalable quantum networks, and achieving powerful quantum-enhanced metrology. In addition to the well-established optomechanical workhorses, novel platforms have emerged, e.g. vibrational and rotational optomechanics of levitated objects, magnomechanics, quantum acoustics, and hybrid spin-mechanical systems. Now, optomechanical platforms enable novel tests of fundamental physics, such as matter-wave interferometry with macroscopic objects, the search for physics beyond the standard model, or deviations from Newtonian gravity at sub-micrometer length scales. This seminar covered recent achievements and future prospects, both theoretically and experimentally, for using mechanical quantum systems to develop new technologies and provide novel tests of fundamental physics.

Conference Budget

Funding provided by the Army Research Office supported partial registration for 3 graduate student, 3 postdocs, 4 professors and 2 assistant professors at the GRC and partial registration for 6 postdocs, 1 assistant professor and 20 graduate students at the GRS.

Conference Feedback

Participants had an opportunity to provide feedback at the end of the Conference. The feedback collected from the meeting was extremely positive. Evaluations included numerous positive remarks including interactive poster sessions, ample opportunities for networking and cutting-edge science. Evaluations from the GRS included positive comments regarding the introduction by the moderators, interactive poster sessions and the cutting edge science presented.

GRC would like to thank the Army Research Office for its continued support of the meetings. The contributions received have been critical to the success of the conferences and are having a measurable impact in advancing the frontiers of science worldwide.

Dr. Klemens Hammerer, GRC Chair
Leibniz Universität Hannover

Dr. Cindy Regal, GRC Chair
JILA, University of Colorado Boulder

Dr. Charles Brown, GRS Chair
Yale University

Dr. Martin Koppenhoefer, GRS Chair
PME, University of Chicago

Dr. Nancy Ryan Gray
President and Chief Executive Officer
Gordon Research Conferences

Mechanical Systems in the Quantum Regime

Gordon Research Conference

Quantum Phononics for Fundamental Measurements and Quantum Technology

June 19 - 24, 2022

Chairs Cindy Regal and Klemens Hammerer

Vice Chairs Thomas P. Purdy and Amir H. Safavi-Naeini

Ventura Beach Marriott

2055 Harbor Boulevard

Ventura, CA, United States

Conference Program

Sunday

- | | |
|-------------------|---|
| 2:00 pm - 9:00 pm | Arrival and Check-in |
| 6:00 pm - 7:00 pm | Dinner |
| 7:30 pm - 7:40 pm | Introductory Comments by GRC Site Staff / Welcome from the GRC Chair |
| 7:40 pm - 9:30 pm | Connecting Quantum Systems with Phonons
Discussion Leader: Amir Safavi-Naeini (Stanford University, United States) |
| 7:40 pm - 8:10 pm | Konrad Lehnert (JILA, University of Colorado, United States)
"Light, Sound, and Circuits" |
| 8:10 pm - 8:20 pm | Discussion |
| 8:20 pm - 8:50 pm | Simon Groeblacher (Delft University of Technology, The Netherlands)
"Generation and Manipulation of Quantum Sound" |
| 8:50 pm - 8:55 pm | Discussion |
| 8:55 pm - 9:25 pm | Kyungjoo Noh (Amazon Web Services, United States)
"Building a Fault-Tolerant Quantum Computer Using Concatenated Cat Codes" |
| 9:25 pm - 9:30 pm | Discussion |

Monday

- | | |
|--------------------|---|
| 7:30 am - 8:30 am | Breakfast |
| 9:00 am - 12:30 pm | Gravitational Wave Detectors
Discussion Leader: Thomas Purdy (University of Pittsburgh, United States) |
| 9:00 am - 9:30 am | Michèle Heurs (Leibniz Universität Hannover, Germany)
"Next Generation Gravitational Wave Observatories on ground and in Space" |
| 9:30 am - 9:40 am | Discussion |
| 9:40 am - 10:10 am | Yanbei Chen (California Institute of Technology, United States) |

"Improving Sensitivities of Gravitational-Wave Detectors using Parametric Amplification and Coherent Quantum Feedback"

10:10 am - 10:20 am	Discussion
10:20 am - 10:50 am	Coffee Break
10:50 am - 11:20 am	Nergis Mavalvala (MIT, United States) "Quantum Mechanical Technologies for Gravitational Wave Detection"
11:20 am - 11:30 am	Discussion
11:30 am - 11:45 am	James Gardner (The Centre for Gravitational Astrophysics @ The Australian National University / OzGrav, Australia) "Nondegenerate Internal Squeezing: An All-Optical, Loss-Resistant Quantum Technique to Enable Kilohertz Gravitational-Wave Detection"
11:45 am - 11:50 am	Discussion
11:50 am - 12:05 pm	Daniel Gould (Australian National University, Australia) "Einstein–Podolsky–Rosen Entangled Interferometers: Quantum Optical Methods for Entangled Devices"
12:05 pm - 12:10 pm	Discussion
12:10 pm - 12:30 pm	General Discussion
12:30 pm - 1:30 pm	Lunch
1:30 pm - 4:00 pm	Free Time
3:00 pm - 4:00 pm	The GRC Power Hour™ <i>The GRC Power Hour™ is designed to address diversity and inclusion in the scientific workplace by providing a safe environment for informal and meaningful conversations amongst colleagues of all career stages. The program supports the professional growth of all members of our communities, including ethnicity, race and/or gender identity by providing an open forum for discussion and mentoring.</i> Organizers: Jack Harris (Yale University, United States) and Eva Weig (Technical University of Munich, Germany)
4:00 pm - 6:00 pm	Poster Session
6:00 pm - 7:00 pm	Dinner
7:30 pm - 9:30 pm	Nonreciprocity and Chirality in Optomechanics Discussion Leader: Ewold Verhagen (AMOLF, The Netherlands)
7:30 pm - 8:00 pm	Anja Metelmann (Free University Berlin, Germany) "Utilizing Nonreciprocity for Quantum Feedback Protocols and Beyond"

8:00 pm - 8:10 pm Discussion

8:10 pm - 8:40 pm **Aashish Clerk** (University of Chicago, United States)
"New Directions in Quantum Non-reciprocity"

8:40 pm - 8:50 pm Discussion

8:50 pm - 9:20 pm **Jack Harris** (Yale University, United States)
"Nonreciprocal Phonon Transfer and the Braiding of Eigenvalues in Optomechanics"

9:20 pm - 9:30 pm Discussion

Tuesday

7:30 am - 8:30 am Breakfast

8:30 am - 9:00 am Group Photo

9:00 am - 12:30 pm **Levitated Optomechanics and Electromechanics**
Discussion Leader: **Tongcang Li** (Purdue University, United States)

9:00 am - 9:30 am **Charles Brown** (Yale University, United States)
"The Optical, Mechanical, and Thermal Properties of Levitated Superfluid Drops"

9:30 am - 9:40 am Discussion

9:40 am - 10:10 am **Benjamin Stickler** (University of Duisburg-Essen, Germany)
"Optical Binding of Nanoparticles: Non-Reciprocal Interactions and Entanglement"

10:10 am - 10:20 am Discussion

10:20 am - 10:50 am Coffee Break

10:50 am - 11:05 am **Julen Pedernales** (University of Ulm, Germany)
"Enhancing Quantum Interactions Between Levitated Solids"

11:05 am - 11:10 am Discussion

11:10 am - 11:40 am **Markus Aspelmeyer** (University of Vienna, Austria)
"Levitated Solids in the Quantum Regime: From Ground State Cooling to Quantum Sources of Gravity"

11:40 am - 11:50 am Discussion

11:50 am - 12:20 pm **Peter Barker** (University College London, United Kingdom)
"A Hybrid Quantum System by Near Field Trapping Cold Atoms Around a Levitated Nanosphere"

12:20 pm - 12:30 pm Discussion

12:30 pm - 1:30 pm Lunch

1:30 pm - 4:00 pm Free Time

4:00 pm - 6:00 pm **Poster Session**

6:00 pm - 7:00 pm Dinner

7:30 pm - 9:30 pm **Fundamental Tests with Mechanical Sensors**
Discussion Leader: **Yiwen Chu** (ETH Zürich, Switzerland)

7:30 pm - 8:00 pm **Swati Singh** (University of Delaware, United States)
"Searching for Dark Matter and Dark Energy with Mechanical Systems"

8:00 pm - 8:10 pm Discussion

8:10 pm - 8:40 pm **Cristian Panda** (University of California Berkeley, United States)
"Testing Gravity by Atom Interferometry with Long Hold Times in an Optical Lattice"

8:40 pm - 8:50 pm Discussion

8:50 pm - 9:20 pm **Jacob Taylor** (Riverlane, United States)
"Impulse Metrology for Fundamental Physics"

9:20 pm - 9:30 pm Discussion

Wednesday

7:30 am - 8:30 am Breakfast

9:00 am - 12:30 pm **Heralding Single Phonons and Quantum Measurements**
Discussion Leader: **Dalziel Wilson** (University of Arizona, United States)

9:00 am - 9:30 am **Philippe Roelli** (CIC nanoGUNE, Spain)
"Room-Temperature Quantum Correlations and Coherent Frequency Conversion using Molecular Optomechanics"

9:30 am - 9:40 am Discussion

9:40 am - 10:10 am **Magdalena Zych** (University of Queensland, Australia)
"Gravity Effects in Quantum Clocks and Sensors: Foundations and Applications"

10:10 am - 10:20 am Discussion

10:20 am - 10:50 am Coffee Break

10:50 am - 11:05 am **Zhujiang Xu** (Purdue University, United States)
"Optomechanics with Quantum Vacuum Fluctuations"

11:05 am - 11:10 am Discussion

11:10 am - 11:40 am **Eugene Polzik** (University of Copenhagen, Denmark)
"Quantum State Processing with Millimeter Size Mechanical Oscillators"

11:40 am - 11:50 am	Discussion
11:50 am - 12:20 pm	Peter Rakich (Yale University, United States) "Towards Quantum Control of High-Frequency Bulk Acoustic Phonons Using Light"
12:20 pm - 12:30 pm	Discussion
12:30 pm - 1:30 pm	Lunch
1:30 pm - 4:00 pm	Free Time
4:00 pm - 6:00 pm	Poster Session
6:00 pm - 7:00 pm	Dinner
7:00 pm - 7:30 pm	Business Meeting <i>Nominations for the Next Vice Chair; Fill in Conference Evaluation Forms; Discuss Future Site and Scheduling Preferences; Election of the Next Vice Chair</i>
7:30 pm - 9:30 pm	Quantum Electromechanical and Magnomechanical Devices Discussion Leader: Eva Weig (Technical University of Munich, Germany)
7:30 pm - 8:00 pm	Adrian Bachtold (ICFO, Spain) "How to Increase Nonlinearities in Nanomechanical Resonators when Approaching the Quantum Regime"
8:00 pm - 8:10 pm	Discussion
8:10 pm - 8:40 pm	Silvia Viola Kusminskiy (Max Planck Institute for the Science of Light, Germany) "Cavity Magnomechanics: Harnessing the Magnomechanical Coupling for Applications in the Microwave and Optical Regimes"
8:40 pm - 8:50 pm	Discussion
8:50 pm - 9:20 pm	John Teufel (NIST Boulder, United States) "Quantum Microwave and Millimeter Wave Optomechanical Circuits"
9:20 pm - 9:30 pm	Discussion
Thursday	
7:30 am - 8:30 am	Breakfast
9:00 am - 12:30 pm	Spin Coupling to Nanomechanics Discussion Leader: Albert Schliesser (University of Copenhagen, Denmark)
9:00 am - 9:30 am	Ania Bleszynski-Jayich (UCSB, United States) "Spin-Coupled Optomechanical Systems in Diamond"
9:30 am - 9:40 am	Discussion
9:40 am - 10:10 am	Christian Degen (ETH Zurich, Switzerland)

	"Nuclear Spin Sensing with Nanomechanical Cantilevers and Membranes"
10:10 am - 10:20 am	Discussion
10:20 am - 10:50 am	Coffee Break
10:50 am - 11:05 am	Prasoon Kumar Shandilya (University of Calgary, Canada) "Optomechanical Interface Between Telecom Photons and Spin Quantum Memory"
11:05 am - 11:10 am	Discussion
11:10 am - 11:40 am	Philipp Treutlein (University of Basel, Switzerland) "Light-Mediated Strong Coupling between a Mechanical Oscillator and Atomic Spins 1 Meter Apart"
11:40 am - 11:50 am	Discussion
11:50 am - 12:20 pm	Tobias Kippenberg (Swiss Federal Institute of Technology Lausanne (EPFL), Switzerland) "Superconducting Circuit Optomechanics in Topological Lattices"
12:20 pm - 12:30 pm	Discussion
12:30 pm - 1:30 pm	Lunch
1:30 pm - 4:00 pm	Free Time
4:00 pm - 6:00 pm	Poster Session
6:00 pm - 7:00 pm	Dinner
7:30 pm - 9:30 pm	Late-Breaking Topics Discussion Leaders: Nancy Aggarwal (Northwestern University, United States)
7:30 pm - 8:00 pm	Raffi Budakian (University of Waterloo, Canada) "Angstrom-Scale Nuclear Magnetic Resonance Diffraction: A Route to Atomic Resolution Magnetic Resonance Imaging"
8:00 pm - 8:10 pm	Discussion
8:10 pm - 8:40 pm	Andrew Cleland (University of Chicago, United States) "Quantum Communication with Phonons"
8:40 pm - 8:50 pm	Discussion
8:50 pm - 9:20 pm	Mohammad Mirhosseini (Caltech, United States) "A Quantum Electromechanical Interface for Long-Lived Phonons"
9:20 pm - 9:30 pm	Discussion
Friday	

7:30 am - 8:30 am Breakfast

9:00 am Departure

Contributors

 <p>Gordon Research Conferences <i>Frontiers of Science</i></p>	 <p>AFOSR AIR FORCE OFFICE OF SCIENTIFIC RESEARCH</p>
 <p>SCIENCE TO SHAPE THE FUTURE OF THE WORLD UNIVERSITY OF MARYLAND 1791</p>	 <p>JPE Driven by innovation</p>
 <p>THE KAVLI NANOSCIENCE INSTITUTE</p>	 <p>Center for Nanoscale Systems Harvard University FAS • SEAS</p>
 <p>JILA pfc an NSF physics frontier center</p>	

This material is based upon work supported by the Air Force Office of Scientific Research under award number FA9550-20-1-0022. Any opinions, finding, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the United States Air Force.

Mechanical Systems in the Quantum Regime (GRS)

Gordon Research Seminar

Optomechanical Systems Enabling Novel Quantum-Enhanced Technologies and Tests of Fundamental Physics

June 18 - 19, 2022

Chairs Charles D. Brown and Martin Koppenhoefer

Ventura Beach Marriott

2055 Harbor Boulevard

Ventura, CA, United States

Conference Program

Saturday

1:00 pm - 5:00 pm	Arrival and Check-in
3:30 pm - 3:45 pm	Introductory Comments by GRC Site Staff / Welcome from the GRS Chair
3:45 pm - 4:30 pm	Keynote Session: Quantum Information Processing with Mechanical Systems Discussion Leader: Bradley Hauer (NIST Boulder, United States)
3:45 pm - 4:20 pm	Yiwen Chu (ETH Zürich, Switzerland) "Quantum Information Processing with Mechanical Systems"
4:20 pm - 4:30 pm	Discussion
4:30 pm - 6:00 pm	Poster Session
6:00 pm - 7:00 pm	Dinner
7:30 pm - 9:30 pm	Optomechanical Sensing and Transduction/Spins Coupled to Mechanics Discussion Leaders: Letizia Catalini (University of Copenhagen, Denmark) and Frankie Fung (Harvard University, United States)
7:30 pm - 7:40 pm	Introduction by Discussion Leader
7:40 pm - 7:55 pm	Maxwell Urmev (JILA / University of Colorado Boulder, United States) "Superconducting Qubit Readout via Low-Backaction Electro-Opto-Mechanical Transduction"
7:55 pm - 8:00 pm	Discussion
8:00 pm - 8:15 pm	Raymond Harrison (The University of Queensland, Australia) "Trapping Sound with Light"
8:15 pm - 8:20 pm	Discussion
8:20 pm - 8:35 pm	Amirali Arabmoheghi (École Polytechnique Fédérale de Lausanne (EPFL), Switzerland) "Sub-Acoustic Wavelength Soft Clamping"
8:35 pm - 8:40 pm	Discussion

8:40 pm - 8:50 pm Introduction by Discussion Leader

8:50 pm - 9:05 pm **Vanessa Wachter** (Max Planck Institute for the Science of Light, Germany)
"Optical Signatures of the Coupled Spin-Mechanics of a Levitated Microparticle"

9:05 pm - 9:10 pm Discussion

9:10 pm - 9:25 pm **Prasoon Kumar Shandilya** (University of Calgary, Canada)
"Optomechanical Interface Between Telecom Photons and Spin Quantum Memory"

9:25 pm - 9:30 pm Discussion

Sunday

7:30 am - 8:30 am Breakfast

9:00 am - 11:00 am **Non-Linear Quantum Systems and Non-Classical State Engineering/Fundamental Physics and Topology**
Discussion Leaders: **Nicolas Diaz Naufal** (Freie Universitaet Berlin, Germany) and **Christian Pluchar** (University of Arizona, United States)

9:00 am - 9:10 am Introduction by Discussion Leader

9:10 am - 9:25 am **Stefan Forstner** (Institute of Photonic Sciences (ICFO), Spain)
"A Nano-Electromechanical Quantum Simulator"

9:25 am - 9:30 am Discussion

9:30 am - 9:45 am **Jiaxin Yu** (Yale University, United States)
"Quantum Optomechanics Using Single Photon Detectors and a Superfluid Helium Resonator"

9:45 am - 9:50 am Discussion

9:50 am - 10:05 am **Gustav Andersson** (University of Chicago, United States)
"Squeezing and Multimode Entanglement of Surface Acoustic Wave Phonons"

10:05 am - 10:10 am Discussion

10:10 am - 10:20 am Introduction by Discussion Leader

10:20 am - 10:35 am **Zhujiang Xu** (Purdue University, United States)
"Quantum Vacuum Mediated Energy Transfer"

10:35 am - 10:40 am Discussion

10:40 am - 10:55 am **Shruti Jose Maliakal** (Caltech, United States)
"Towards Realizing a Tabletop Opto-Mechanical Phase-Sensitive Amplifier"

10:55 am - 11:00 am Discussion

11:00 am - 12:30 pm	Poster Session <i>Coffee will be served in the poster area from 11:00 am - 11:30 am</i>
12:30 pm - 1:30 pm	Lunch
1:30 pm - 2:30 pm	Levitated Systems Discussion Leader: Mario Arnolfo Ciampini (University of Vienna, Austria)
1:30 pm - 1:45 pm	Massimiliano Rossi (ETH Zürich, Switzerland) "Quantum Optomechanics with an Optically Levitated Nanosphere"
1:45 pm - 1:50 pm	Discussion
1:50 pm - 2:05 pm	Kirill Streltsov (Ulm University, Germany) "Quantum Control of a Levitated Particle via a Two-Level System for Ground-State Cooling and Interaction Enhancement"
2:05 pm - 2:10 pm	Discussion
2:10 pm - 2:25 pm	Muddassar Rashid (King's College London, United Kingdom) "A Highly Efficient Underdamped Heat Engine"
2:25 pm - 2:30 pm	Discussion
2:30 pm - 3:00 pm	Evaluation Period <i>Fill in GRS Evaluation Forms</i>
3:00 pm	Seminar Concludes

Contributors



National Society of Black Physicists (NSBP)



This material is based upon work supported by the Air Force Office of Scientific Research under award number FA9550-20-1-0022. Any opinions, finding, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the United States Air Force.

GRC Attendee List

The list of attendees appears below, sorted by the role recorded in their registration record.

Name	Affiliation	Participation	Gender
Hammerer, Klemens	Leibniz Universität Hannover	Chair	Male
Regal, Cindy	JILA, University of Colorado Boulder	Chair	Female
Purdy, Thomas P	University of Pittsburgh	Vice Chair	Male
Safavi-Naeini, Amir H	Stanford University	Vice Chair	Male
Aspelmeyer, Markus	University of Vienna	Speaker	Male
Bachtold, Adrian	ICFO	Speaker	Male
Barker, Peter	University College London	Speaker	Male
Bleszynski-Jayich, Ania	UCSB	Speaker	Female
Brown, Charles D	Yale University	Speaker	Male
Budakian, Raffi	University of Waterloo	Speaker	Male
Chen, Yanbei	California Institute of Technology	Speaker	Male
Cleland, Andrew N	University of Chicago	Speaker	Male
Clerk, Aashish	University of Chicago	Speaker	Male
Degen, Christian	ETH Zurich	Speaker	Male
Gardner, James W	The Centre for Gravitational Astrophysics @ The Australian National University / OzGrav	Speaker	Male
Gould, Daniel W	Australian National University	Speaker	Male
Groeblicher, Simon	Delft University of Technology	Speaker	Male
Harris, Jack G. E	Yale University	Speaker	Male
Heurs, Michèle	Leibniz Universität Hannover	Speaker	Female
Kippenberg, Tobias J.	Swiss Federal Institute of Technology Lausanne (EPFL)	Speaker	Male
Lehnert, Konrad W	JILA, University of Colorado	Speaker	Male
Mavalvala, Nergis	MIT	Speaker	Female
Metelmann, Anja	Free University Berlin	Speaker	Female
Mirhosseini, Mohammad	Caltech	Speaker	Male
Noh, Kyungjoo	Amazon Web Services	Speaker	Male
Panda, Cristian D	University of California Berkeley	Speaker	Male
Pedernales, Julen S.	University of Ulm	Speaker	Male
Polzik, Eugene	University of Copenhagen	Speaker	Male
Rakich, Peter	Yale University	Speaker	Male
Roelli, Philippe	CIC nanoGUNE	Speaker	Male
Shandilya, Prasoon Kumar	University of Calgary	Speaker	Male
Singh, Swati	University of Delaware	Speaker	Female
Stickler, Benjamin A.	University of Duisburg-Essen	Speaker	Male
Taylor, Jacob	Riverlane	Speaker	Male
Teufel, John	NIST Boulder	Speaker	Male
Treutlein, Philipp	University of Basel	Speaker	Male
Viola Kusminskiy, Silvia	Max Planck Institute for the Science of Light	Speaker	Female

Name	Affiliation	Participation	Gender
Xu, Zhujing	Purdue University	Speaker	Female
Zych, Magdalena	University of Queensland	Speaker	Female
Aggarwal, Nancy	Northwestern University	Discussion Leader	Female
Chu, Yiwen	ETH Zürich	Discussion Leader	Female
Li, Tongcang	Purdue University	Discussion Leader	Male
Schliesser, Albert	University of Copenhagen	Discussion Leader	Male
Verhagen, Ewold	AMOLF	Discussion Leader	Male
Weig, Eva M	Technical University of Munich	Discussion Leader	Female
Wilson, Dalziel J	University of Arizona	Discussion Leader	Male
Adachi, Kazemi	JILA, NIST, CU Boulder	Poster Presenter	Male
Alder, Fiona A	University College London	Poster Presenter	Female
Andersen, Ulrik L	Technical University of Denmark (DTU)	Poster Presenter	Male
Andersson, Gustav	University of Chicago	Poster Presenter	Male
Arabmoheghi, Amirali	École Polytechnique Fédérale de Lausanne	Poster Presenter	Male
Arrazola, Iñigo	Technische Universität Wien	Poster Presenter	Male
Benevides, Rodrigo	ETH Zürich	Poster Presenter	Male
Betz, Joey	University of Delaware	Poster Presenter	Male
Blencowe, Miles P	Dartmouth College	Poster Presenter	Male
Borne, Adrien	Université Paris Cité	Poster Presenter	Male
Bosch Aguilera, Manel	University of Basel	Poster Presenter	Male
Burgwal, Roel	AMOLF	Poster Presenter	Male
Burrell, Nia	Northwestern University	Poster Presenter	Female
Cagetti, Marta	ICFO-The Institute of Photonic Sciences	Poster Presenter	Female
Catalini, Letizia	University of Copenhagen	Poster Presenter	Female
Chen, Junxin	LIGO MIT	Poster Presenter	Male
Chou, Ming-Han	University of Chicago	Poster Presenter	Male
Ciampini, Mario Arnolfo	University of Vienna	Poster Presenter	Male
Clark, Thomas J	Mcgill	Poster Presenter	Male
Davis, John P	University of Alberta, Dept of Physics	Poster Presenter	Male
de Jong, Matthijs H.J.	Delft University of Technology	Poster Presenter	Male
DeCrescent, Ryan A	NIST Boulder	Poster Presenter	Male
Delic, Uros	University of Vienna	Poster Presenter	Male
Demiralp, Berke	Technical University of Munich	Poster Presenter	Male
Dey Chowdhury, Mitul	University of Arizona	Poster Presenter	Male
Dharod, Viraj H	UCSB Physics Department	Poster Presenter	Male
Diaz Naufal, Nicolas	Freie Universitaet Berlin	Poster Presenter	Male
do Carmo Carvalho, Natalia	University of Calgary	Poster Presenter	Female
Dumont, Vincent	McGill University	Poster Presenter	Male
Emsler, Alec L	JILA / CU Boulder	Poster Presenter	Male
Engelsen, Nils Johan	Ecole Polytechnique Fédérale de Lausanne	Poster Presenter	Male
Ernzer, Maryse	University of Basel	Poster Presenter	Female

Name	Affiliation	Participation	Gender
Fefferman, Andrew	Institut Néel/CNRS	Poster Presenter	Male
Fiaschi, Niccolo'	TU Delft	Poster Presenter	Unspecified
Fogliano, Francesco	University Basel	Poster Presenter	Male
Forstner, Stefan	Institute of Photonic Sciences (ICFO)	Poster Presenter	Male
Fratini, Nicholas	University of Colorado Boulder	Poster Presenter	Male
Fu, Hayden S. H.	University College London	Poster Presenter	Male
Fung, Frankie	Harvard University	Poster Presenter	Male
Ghosh, Sohritri	University of Maryland, College Park	Poster Presenter	Female
Gisler, Thomas	ETH Zurich	Poster Presenter	Male
Golokolenov, Ilya	Institut Néel	Poster Presenter	Male
Gonzalez-Ballesterro, Carlos	Institute for Quantum Optics and Quantum Information	Poster Presenter	No Answer
Goschin, Florian	University of Innsbruck	Poster Presenter	Male
Gosling, Jonathan MH	University College London	Poster Presenter	Male
Gut, Corentin	Universitaet Wien	Poster Presenter	Unspecified
Hälg, David	ETH Zürich	Poster Presenter	Male
hao, shan	Department of Physics and Astronomy, University of Pittsburgh	Poster Presenter	Male
Harrison, Raymond A	The University of Queensland	Poster Presenter	Male
Hauer, Bradley D	NIST Boulder	Poster Presenter	Male
Hirschel, Marvin	University of Alberta	Poster Presenter	Male
Høj, Dennis H	Technical University of Denmark	Poster Presenter	Male
Huebl, Hans	Walther-Meissner-Institut	Poster Presenter	Male
James, Robert S	University College London	Poster Presenter	Male
Jiang, Wentao	Stanford University	Poster Presenter	Male
Johnson, Aisling	Quantum Optics, Quantum Nanophysics and Quantum Information	Poster Presenter	Female
Jose Maliakal, Shruti	Caltech	Poster Presenter	Female
Ju, Peng	Purdue University	Poster Presenter	Male
Kilian, Eva	University College London	Poster Presenter	Female
Kirchmair, Gerhard	Institute for Quantum Optics and Quantum Information, Austrian Academy of Sciences	Poster Presenter	Male
Kono, Shingo	EPFL	Poster Presenter	Male
Koppenhoefer, Martin	PME, University of Chicago	Poster Presenter	Male
Kotler, Shlomi S	Hebrew University of Jerusalem	Poster Presenter	Male
Kristensen, Mads B.	Niels Bohr Institute, University of Copenhagen	Poster Presenter	Male
Kustura, Katja	Institute for Quantum Optics and Quantum Information (IQOQI) / University of Innsbruck	Poster Presenter	Female
Lane, Justin R	Yale University	Poster Presenter	Male
Lane, Benjamin B	MIT - LIGO Laboratory	Poster Presenter	Male
Lawall, John R	National Institute of Standards and Technology	Poster Presenter	Male

Name	Affiliation	Participation	Gender
Le, Anh Tuan	Technical University of Munich	Poster Presenter	Male
Lingenfelter, Andrew	University of Chicago	Poster Presenter	Male
Lodde, Matteo	Eindhoven University of Technology	Poster Presenter	Male
Luo, Yizhi	Yale University	Poster Presenter	Male
Luschmann, Thomas	Walther-Meißner-Institut	Poster Presenter	Male
Lyyra, Henri	University of Jyväskylä	Poster Presenter	Male
Mayor, Felix	Stanford University	Poster Presenter	Male
Militaru, Andrei	ETH Zurich	Poster Presenter	Male
Millen, James	King's College London	Poster Presenter	Male
Mittal, Sarang	CU Boulder/JILA	Poster Presenter	Male
Moller, Christoffer Bo	ICFO - The Institute of Photonic Sciences	Poster Presenter	Male
Muhonen, Juha T	University of Jyväskylä	Poster Presenter	Male
Norte, Richard A	Delft University of Technology	Poster Presenter	Male
Oh, Hyunseok	University of California, Santa Barbara	Poster Presenter	Male
Padgett, Carl	UCSB	Poster Presenter	Male
Patil, Yogesh S S	Yale University	Poster Presenter	Male
Pautrel, Samuel	Laboratoire MPQ - Université Paris Cité	Poster Presenter	Male
Pelka, Karl A	University of Malta	Poster Presenter	Male
Penny, Thomas W	University College London	Poster Presenter	Male
Planz, Eric	Niels Bohr Institute	Poster Presenter	Male
Pluchar, Christian M	University of Arizona	Poster Presenter	Male
Pontin, Antonio	University College London	Poster Presenter	Male
Potts, Clinton A	University of Alberta	Poster Presenter	Male
Premawardhana, Gayathrini T	University of Maryland - College Park	Poster Presenter	Female
Puglia, Denise	IST Austria	Poster Presenter	Female
Rademacher, Markus	University College London	Poster Presenter	Male
Rashid, Muddassar	King's College London	Poster Presenter	Male
Reetz, Christopher	JILA	Poster Presenter	Male
Rodrigues, Ines C.	ETH Zurich	Poster Presenter	Female
Rossi, Massimiliano	ETH Zürich	Poster Presenter	Male
Rudolph, Henning	University of Duisburg-Essen	Poster Presenter	Male
Ryu, Younghun	KAIST	Poster Presenter	Male
Sánchez Arribas, Irene	Technical University of Munich	Poster Presenter	Female
Schatteburg, Tom	ETH Zürich	Poster Presenter	Male
Schmid, Gian-Luca	University of Basel	Poster Presenter	Male
Schmidt, Mikolaj K	Macquarie University	Poster Presenter	Male
Schulte, Bernd W	Institute for Gravitational Physics Leibniz University Hannover	Poster Presenter	Male
Sementilli, Leo	University of Queensland	Poster Presenter	Male
Shakespeare, Cliona	University of Jyväskylä	Poster Presenter	Female
Siegel, Benjamin	Yale University	Poster Presenter	Male

Name	Affiliation	Participation	Gender
Silverman, Kevin	NIST - Boulder	Poster Presenter	Male
Steele, Gary	Delft University of Technology	Poster Presenter	Male
Steiner, Marit O. E.	Ulm University	Poster Presenter	Female
Streltsov, Kirill	Ulm University	Poster Presenter	Male
Suh, Junho	Korea Research Institute of Standards and Science	Poster Presenter	Male
Sun, Peter	Cornell University	Poster Presenter	Male
Talamo, Luca G	JILA	Poster Presenter	Male
Urmey, Maxwell D	JILA / University of Colorado Boulder	Poster Presenter	Male
van Soest, Jean-Paul	Delft University of Technology	Poster Presenter	Male
Vandersmissen, Jente	AMOLF	Poster Presenter	Male
Vitali, David	University of Camerino	Poster Presenter	Male
Vogt, Christian	ZARM, University of Bremen	Poster Presenter	Male
Wachter, Vanessa	Max Planck Institute for the Science of Light	Poster Presenter	Female
Wang, Yiqi	Yale University	Poster Presenter	Male
Wasserman, Walter W	School of Mathematics and Physics, University of Queensland	Poster Presenter	Male
Wieczorek, Witlef	Chalmers University of Technology	Poster Presenter	Male
Winkler, Klemens	Vienna Center for Quantum Science and Technology (VCQ), Faculty of Physics, University of Vienna	Poster Presenter	Male
Xie, Jiacheng	Yale University	Poster Presenter	Male
Xuereb, André	University of Malta	Poster Presenter	Male
Yang, Yu	ETHz	Poster Presenter	Male
Yu, Jiaxin	Yale University	Poster Presenter	Female
Zeuthen, Emil	Niels Bohr Institute, University of Copenhagen	Poster Presenter	Male
Zivari, Amirparsa	Technical University of Delft	Poster Presenter	Male
Zoepfl, David	IQOQI, Austrian Academy of Sciences	Poster Presenter	Male
Barclay, Paul	University of Calgary	Attendee	Male
Bhave, Sunil A	Purdue University	Attendee	Male
Bowen, Warwick	University of Queensland	Attendee	Male
Bozkurt, Alkim B	Caltech	Attendee	Male
Direkci, Su	Caltech	Attendee	Female
Juan, Mathieu	Université de Sherbrooke - Institut quantique	Attendee	Male
Schiulaz, Mauro	American Physical Society	Attendee	Male
Shomroni, Itay	HUJI	Attendee	Male
Stamp, Philip C.E.	University of British Columbia	Attendee	Male
Wilson-Gerow, Jordan	Caltech	Attendee	Male
Zhao, Han	California Institute of Technology	Attendee	Male

GRS Attendee List

The list of attendees appears below, sorted by the role recorded in their registration record.

Note: Only one primary role is recorded for each registration record, even if the attendee served in multiple roles at the meeting. The recorded role is based on the order of precedence listed below.

Name	Affiliation	Participation	Gender
Brown, Charles D	Yale University	Chair	Male
Koppenhoefer, Martin	PME, University of Chicago	Chair	Male
Andersson, Gustav	University of Chicago	Speaker	Male
Arabmoheghi, Amirali	École Polytechnique Fédérale de Lausanne (EPFL)	Speaker	Male
Chu, Yiwen	ETH Zürich	Speaker	Female
Forstner, Stefan	Institute of Photonic Sciences (ICFO)	Speaker	Male
Harrison, Raymond A	The University of Queensland	Speaker	Male
Jose Maliakal, Shruti	Caltech	Speaker	Female
Rashid, Muddassar	King's College London	Speaker	Male
Rossi, Massimiliano	ETH Zürich	Speaker	Male
Shandilya, Prasoon Kumar	University of Calgary	Speaker	Male
Streltsov, Kirill	Ulm University	Speaker	Male
Urmey, Maxwell D	JILA / University of Colorado Boulder	Speaker	Male
Wachter, Vanessa	Max Planck Institute for the Science of Light	Speaker	Female
Xu, Zhujing	Purdue University	Speaker	Female
Yu, Jiaxin	Yale University	Speaker	Female
Catalini, Letizia	University of Copenhagen	Discussion Leader	Female
Ciampini, Mario Arnolfo	University of Vienna	Discussion Leader	Male
Diaz Naufal, Nicolas	Freie Universitaet Berlin	Discussion Leader	Male
Fung, Frankie	Harvard University	Discussion Leader	Male
Hauer, Bradley D	NIST Boulder	Discussion Leader	Male
Pluchar, Christian M	University of Arizona	Discussion Leader	Male
Adachi, Kazemi	JILA, NIST, CU Boulder	Poster Presenter	Male
Benevides, Rodrigo	ETH Zürich	Poster Presenter	Male
Bosch Aguilera, Manel	University of Basel	Poster Presenter	Male
Burgwal, Roel	AMOLF	Poster Presenter	Male
Chen, Junxin	LIGO MIT	Poster Presenter	Male
Delic, Uros	University of Vienna	Poster Presenter	Male
Demiralp, Berke	Technical University of Munich	Poster Presenter	Male
Dharod, Viraj H	UCSB Physics Department	Poster Presenter	Male
do Carmo Carvalho, Natalia	University of Calgary	Poster Presenter	Female
Dumont, Vincent	McGill University	Poster Presenter	Male
Emser, Alec L	JILA / CU Boulder	Poster Presenter	Male
Ernzer, Maryse	University of Basel	Poster Presenter	Female
Fiaschi, Niccolo'	TU Delft	Poster Presenter	Unspecified

Name	Affiliation	Participation	Gender
Gardner, James W	The Centre for Gravitational Astrophysics @ The Australian National University / OzGrav	Poster Presenter	Male
Ghosh, Sohritri	University of Maryland, College Park	Poster Presenter	Female
Gisler, Thomas	ETH Zurich	Poster Presenter	Male
Goschin, Florian	University of Innsbruck	Poster Presenter	Male
Gosling, Jonathan MH	University College London	Poster Presenter	Male
Gould, Daniel W	Australian National University	Poster Presenter	Male
Gut, Corentin	Universitaet Wien	Poster Presenter	Unspecified
Hälg, David	ETH Zürich	Poster Presenter	Male
hao, shan	Department of Physics and Astronomy, University of Pittsburgh	Poster Presenter	Male
Hirschel, Marvin	University of Alberta	Poster Presenter	Male
James, Robert S	University College London	Poster Presenter	Male
Jiang, Wentao	Stanford University	Poster Presenter	Male
Kono, Shingo	EPFL	Poster Presenter	Male
Kristensen, Mads B.	Niels Bohr Institute, University of Copenhagen	Poster Presenter	Male
Kustura, Katja	Institute for Quantum Optics and Quantum Information (IQOQI) / University of Innsbruck	Poster Presenter	Female
Lane, Justin R	Yale University	Poster Presenter	Male
Lane, Benjamin B	MIT - LIGO Laboratory	Poster Presenter	Male
Le, Anh Tuan	Technical University of Munich	Poster Presenter	Male
Lodde, Matteo	Eindhoven University of Technology	Poster Presenter	Male
Luschmann, Thomas	Walther-Meißner-Institut	Poster Presenter	Male
Lyyra, Henri	University of Jyväskylä	Poster Presenter	Male
Militaru, Andrei	ETH Zurich	Poster Presenter	Male
Mittal, Sarang	CU Boulder/JILA	Poster Presenter	Male
Oh, Hyunseok	University of California, Santa Barbara	Poster Presenter	Male
Padgett, Carl	UCSB	Poster Presenter	Male
Patil, Yogesh S S	Yale University	Poster Presenter	Male
Pautrel, Samuel	Laboratoire MPQ - Université Paris Cité	Poster Presenter	Male
Pelka, Karl A	University of Malta	Poster Presenter	Male
Penny, Thomas W	University College London	Poster Presenter	Male
Planz, Eric	Niels Bohr Institute	Poster Presenter	Male
Potts, Clinton A	University of Alberta	Poster Presenter	Male
Premawardhana, Gayathrini T	University of Maryland - College Park	Poster Presenter	Female
Puglia, Denise	IST Austria	Poster Presenter	Female
Reetz, Christopher	JILA	Poster Presenter	Male
Rodrigues, Ines C.	ETH Zurich	Poster Presenter	Female
Sánchez Arribas, Irene	Technical University of Munich	Poster Presenter	Female
Schatteburg, Tom	ETH Zürich	Poster Presenter	Male
Schmid, Gian-Luca	University of Basel	Poster Presenter	Male

Name	Affiliation	Participation	Gender
Schulte, Bernd W	Institute for Gravitational Physics Leibniz University Hannover	Poster Presenter	Male
Shakespeare, Cliona	University of Jyväskylä	Poster Presenter	Female
Steiner, Marit O. E.	Ulm University	Poster Presenter	Female
Talamo, Luca G	JILA	Poster Presenter	Male
van Soest, Jean-Paul	Delft University of Technology	Poster Presenter	Male
Vandersmissen, Jente	AMOLF	Poster Presenter	Male
Vogt, Christian	ZARM, University of Bremen	Poster Presenter	Male
Wasserman, Walter W	School of Mathematics and Physics, University of Queensland	Poster Presenter	Male
Winkler, Klemens	Vienna Center for Quantum Science and Technology (VCQ), Faculty of Physics, University of Vienna	Poster Presenter	Male
Zivari, Amirparsa	Technical University of Delft	Poster Presenter	Male
Zoepfl, David	IQOQI, Austrian Academy of Sciences	Poster Presenter	Male