QUANTUM CONCEPTS IN ENHANCING SENSING AND IMAGING TECHNOLOGIES: APPLICATIONS FOR BIOLOGY

AGENDA

Virtual Workshop
March 8–10, 2021
11:00 a.m.–4:00 p.m.
All times listed are in Eastern Time

Monday, March 8, 2021

10:30 Virtual Platform Opens

11:00 Opening Remarks
- *Steven Moss,* The National Academies of Sciences, Engineering, and Medicine
- *Todd Anderson,* U.S. Department of Energy
- *Taekjip Ha,* Johns Hopkins University* *(Chair)*

11:15 Keynote Address
- *Thorsten Ritz,* University of California, Irvine

11:45 Keynote Address
- *Marlan O. Scully,* Texas A&M University

12:15 Break

12:20 Session 1 – Probing intracellular and intercellular correlations in biology

Description: Biological systems are characterized by the dynamic organization of multiscale physical processes in nonequilibrium environments. Sensing and imaging tools derived from terahertz spectroscopy, fluorescence correlation spectroscopy, optogenetics, nuclear magnetic resonance, and various arenas of quantum information science are important to understanding these characterizations. We aim to further understand: 1) How these technologies may be poised to elucidate a range of phenomena across intracellular and intercellular domains and 2) how such novel approaches could be transformative in shaping our ability to manipulate and engineer biological systems for energy and information processing applications.

Moderator: *Philip Kurian,* Howard University*

Panelists:
- *Marco Pettini,* Aix-Marseille Université (France)
- *Allyson E. Sgro,* Boston University
- *Martin Plenio,* Ulm University (Germany)
- *Gürol M. Süel,* University of California, San Diego

1:15 Break

1:30 Session 2 – Bioelectromagnetic fields

Description: Nanoscale interactions with electromagnetic fields might be impactful for biology. Through the study of these interactions, we aim to answer the following questions: 1) What are needed and existing tools to demonstrate the presence, causality, and consequences of such interactions? 2) To which extent are these interactions "quantum"? 3) How might organisms regulate them in vivo? 4) How can they be manipulated to technological and therapeutic advantage?

Moderator: *Clarice D. Aiello,* University of California, Los Angeles*

Panelists:
- *Margaret Ahmad,* Sorbonne University (France)

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- *Wendy Beane,* Western Michigan University
- *Douglas C. Wallace,* University of Pennsylvania
- *Michael Levin,* Tufts University

2:25 Break

2:30 **Session 3 – Quantum photonics in biological systems**

Description: Quantum optics and photonics intersect at various scales in biological systems. Related to this, scientists are seeking to unravel the role of coherence in the spatial and temporal dynamics of these systems. To study these coherences, researchers are bridging across spectroscopy approaches to understand these biological quantum systems, and further understand energy and charge transfer. This session will explore how different techniques are advancing the study of photonics in biological systems, and what the major challenges are to advancing this research.

Moderator: *Prineha Narang,* Harvard University*

Panelists:

- *Michelle Digman,* University of California, Irvine
- *Scott K. Cushing,* California Institute of Technology
- *Giuseppe Luca Celardo,* Benemérita Universidad Autónoma de Puebla (Mexico)
- *Tjaart Krüger,* University of Pretoria (South Africa)

3:25 **Transition to Breakout Groups**

During this transition time, we encourage you to move around the virtual platform and explore the different rooms and capabilities. Please navigate to the breakout group map within 5-10 minutes.

Breakout Groups

Self-select a table to join. We encourage your group to discuss the day's topics by answering the pre-populated questions and connecting with workshop attendees and speakers.

4:00 **Adjourn Day 1**

The virtual platform will stay open until 5:00p.m. for informal networking.

5:00 **Virtual Platform Closes**

Tuesday, March 9, 2021

10:30 **Virtual Platform Opens**

11:00 **Joint Keynote Address**

- *Karl K. Berggren,* Massachusetts Institute of Technology
- *Elizabeth Villa,* University of California, San Diego

11:45 Break

11:50 **Session 4 – Quantum principles for enhanced measurement and imaging in microscopy**

Description: Advances in microscopy have managed to unlock details of biology on a number of different scales, from single-molecule observations to multi-cellular imaging. This session will explore advances in using quantum-enabled microscopy to understand properties of biological systems, as well as the potential that exists in applying emerging microscopy technologies to explore different biological entities.

Moderator: *Prem Kumar,* Northwestern University*

Panelists:

- *Theodore Goodson III,* University of Michigan
- *Ted A. Laurence,* Lawrence Livermore National Laboratory
- *Melissa Skala,* University of Wisconsin - Madison

12:45 Break

1:00 **Session 5 – Broadband spectroscopies of collective dynamics in biology**

Description: Quantum-enhanced measurement and imaging is a multifaceted and rapidly expanding

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field of research that promises to shed new light on biological systems. The aim of this session is to discuss metrology and microscopy of dynamics in biological systems in conditions of low-light, special spectral ranges, and the promise of using the non-classical properties of light for quantum-enhanced imaging.

Moderator: *Prineha Narang,* Harvard University*
Panelists:
- *Prem Kumar,* Northwestern University*
- *Philip Hemmer,* Texas A&M University
- *Kim Lewis,* Howard University
- *Michelle A. O'Malley,* University of California, Santa Barbara

1:55 Break

2:00 Session 6 – Ultrafast spectroscopy and biological reporters

Description: Networks of aromatic molecules, characterized by specific delocalized charge responses, are ubiquitous in biology. The fundamental principles of fluorescence for these quantum reporters of biological behavior, have been understood for decades. More recently, work has started to explore properties across the entire UV-visible-IR spectrum at sub-picosecond scales. This session looks to understand how multidimensional spectroscopies probing the cooperative and coherent behaviors of protein and nucleic acid complexes could be game-changing in studies of the interaction of light and living systems.

Moderator: *Philip Kurian,* Howard University*
Panelists:
- *Majed Chergui,* EPFL
- *Dongping Zhong,* Ohio State University
- *Michelle Sander,* Boston University
- *Bern Kohler,* Ohio State University

2:45 Break

Utilize this break as an opportunity for informal networking and to navigate to the Poster Hall map.

3:10 Poster Session

In the Poster Hall map, there are two floors with presenters and at each station, a maximum of 4 people are allowed at one time.

4:00 Adjourn Day 2

The virtual platform will stay open until 5:00p.m. for informal networking.

5:00 Virtual Platform Closes

Wednesday, March 10, 2021

10:30 Virtual Platform Opens

11:00 Welcome and Summary of Days 1 and 2
- *Taekjip Ha,* Johns Hopkins University* *(Chair)*

11:15 Keynote Address
- *Michelle A. O'Malley,* University of California, Santa Barbara

11:45 Break

11:50 Session 7 – Current capabilities and limitations in plant imaging

Description: Microscopy allows us to visualize and quantify those fundamental processes that govern plant growth, cell division and differentiation, sensing and response to the environment, protection from pathogens, and the wide array of interactions that constitute symbioses. A varied and exciting range of tools are being developed to allow ever more precise characterization of organellar, cellular, and tissue-scale processes. This session will examine new and emerging approaches to plant imaging

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that exist on either side of the quantum/classical boundary, with an effort to explore as-yet unattainable information that may be found using quantum approaches.

Moderator: *Jason B. West,* Texas A&M University*
Panelists:
- *Ross Sozzani,* North Carolina State University
- *Keiko Torii,* University of Texas at Austin
- *Christopher N. Topp,* Donald Danforth Plant Research Center

12:45 **Break**

1:00 **Session 8 – Measurement and sensing needs for microbial communities**

Description: This session will discuss the critical knowledge gaps in our understanding of functionality and interactions in environmental microbiomes and current limitations of existing imaging techniques—specifically time-resolution, 3D imaging, molecular sensitivity, and phototoxicity—that could be overcome with quantum approaches.

Moderator: *Jennifer Pett-Ridge,* Lawrence Livermore National Laboratory*
Panelists:
- *Victoria J. Orphan,* California Institute of Technology
- *Alice Dohnalkova,* Pacific Northwest National Laboratory
- *Elizabeth A. Shank,* University of Massachusetts Medical School

1:55 **Break**

2:00 **Session 9 – Education, training, and workforce needs to move the quantum biology community forward**

Description: In this session, we will discuss what the community building and education needs are in working to establish a quantum biology workforce. We aim to answer the following questions: 1) What are current models for quantum biology education? 2) How are interdisciplinary challenges addressed during the training of the workforce? 3) How do we attract and establish a diverse and inclusive quantum biology workforce?

Moderator: *Clarice D. Aiello,* University of California, Los Angeles*
Panelists:
- *Johnjoe McFadden,* University of Surrey (United Kingdom)
- *Thomas A. Searles,* Howard University

2:55 **Closing Remarks and Breakout Session Instructions**
- *Taekjip Ha,* Johns Hopkins University* *(Chair)*

3:00 **Townhall-style Breakout Groups and Informal Networking**

Navigate to the breakout group map and self-select a table to begin group discussions.

4:00 **Adjourn Day 3**

The virtual platform will stay open until 5:00p.m. for informal networking.

* Member of the workshop organizing committee

Have questions about the virtual platform?
Email Kelly (kelly.hedgecock@eposterboards.com)

Have questions about the workshop?
Email Steven (smoss@nas.edu)