OVERVIEW

This meeting is generously sponsored by the Gordon & Betty Moore Foundation, with administrative support from the Electrical and Computer Engineering Department at UCLA.

Co-chairs: Thorsten Ritz, UC Irvine
Clarice D. Aiello, UCLA

Key questions for the meeting:

1. What processes in biology might sustain coherent spin interactions?

2. What are available experimental data consistent/inconsistent with such interactions? What existing theoretical models account for the above data?

3. What strong research tools exist to demonstrate the presence, causality and consequences of potential coherent spin interactions? What are needed research tools?

4. If such coherent spin interactions exist, how might organisms regulate them in vivo? How do coherence times impact sensitivity? How, if at all, can coherent spin interactions in biology be manipulated to technological and therapeutic advantage?

5. Can coherent spin physics be unambiguously established – or refuted! – to account for physiologically relevant biological phenomena?

Talks and discussions will be webcast through a Zoom link, https://ucla.zoom.us/j/6177105261 (or room # 617 710 5261).

This discussion-based workshop is heavily inspired by another workshop organized by Douglas Brash ('Chemiexcitation in Human Disease', Cold Spring Harbour Laboratory, 2017). We are deeply grateful for his advice and for his sharing of experience.
8.15–8.30 am: Opening remarks by Jeff Miller, UCLA and Director of the California NanoSystems Institute

8.30–9.15 am: Keynote address by Mikhail Lukin, Harvard University
Probing biological systems with quantum sensors

Session 1: Introduction and overview
Chair: Thorsten Ritz
9.15–9.25 am: Clarice D. Aiello, UCLA
Discussion: key questions for the meeting
9.25–9.45 am: Thorsten Ritz, UC Irvine
Coherent spin interactions in biology: avian magnetoreception – and beyond

Session 2: Emerging potential evidence of coherent spin physics phenomena in biology
Chair: Justin Caram — Agent provocateur: Clarice D. Aiello
10.15–10.35 am: Margaret Ahmad, Sorbonne University and CNRS
Cryptochromes and perception of electromagnetic fields
10.35–10.55 am: Wendy Beane, Western Michigan University
Controlling stem cell proliferation with weak magnetic fields:
a case for spin dynamics and free radical manipulation
10.55–11.15 am: Zoya Leonenko, University of Waterloo
Effect of Li isotopes in neuronal signal propagation
11.15–11.35 am: Luca Turin, Biomedical Sciences Research Center Alexander Fleming
Electron spins in the brain of fruit flies
11.35–12.25 pm: Discussion: unresolved issues for the chalkboard (led by Caram and Aiello)
• Where would biologists/chemists suggest physicists to look for coherent spin phenomena?
• What do biologists/chemists consider the unexplained steps in their experiments?
• What are main theoretical objections against coherent spin processes in biology?

Session 3: Before spin coherence: the necessary ingredients
Chair: Yuval Kolodny — Agent provocateur: Douglas Brash
2.00–2.20 pm: Johnjoe McFadden, Leverhulme Quantum Biology Centre and University of Surrey
Can biology live without quantum mechanics?
2.20–2.40 pm: Daniel Kattnig, Living Systems Institute and University of Exeter
Cryptochrome magnetoreception beyond established paradigms
2.40–3.00 pm: Matthew Fisher, UC Santa Barbara
Quantum processing in the brain with nuclear spins?
3.00–3.20 pm: Nicole Yunger Halpern, Harvard University
Quantum information in the Posner model of quantum cognition
3.20–3.40 pm: Daniel Manzano, University of Granada
Spin dynamics in quantum and classical non-equilibrium systems
3.40–4.10 pm: Discussion: unresolved issues for the chalkboard (led by Usselman and Brash)
• In which biological phenomena do these ingredients appear?
• What are alternative explanations?
• What are the limitations of the models?
• What are main theoretical objections against coherent spin processes in biology?
• If coherence is at play in biology, does it/was it ‘selected to’ enhance performance?

Session 4: Potato, potato: are we talking about the same thing? Disease, genetics, metabolism
Chair: Wendy Beane — Agent provocateur: Daniel Kattnig
4.40–5.00 pm: Douglas Wallace, University of Pennsylvania
   A mitochondrial bio-energetic etiology of disease
5.00–5.20 pm: Douglas Brash, Yale School of Medicine
   Chemiexcitation and biological Achilles’ heels
5.20–5.40 pm: Graham Timmins, University of New Mexico
   Quantum mechanics to enhance drug activity
5.40–6.00 pm: Alex Jones, National Physical Laboratory
   The unusual and varied spin dynamics of vitamin B12
6.00–6.30 pm: Discussion: unresolved issues for the chalkboard (led by Beane and Kattnig)
   • Are we all talking about the same/a similar spin mechanism?
   • What might be implications of coherent spin physics for health and therapy?
   • Can we probe/control metabolism and disease via spin physics?
Session 5: The white paper, brainstorm
Chair: Clarice D. Aiello
8.30–8.50 am: Remarks on goal to be accomplished;
break into three groups by field of training:

A ~ biology
B ~ chemistry
C ~ physics and engineering

8.50–9.20 am: Each breakout field develops a list of:

• ‘principles’ + good reviews and textbooks
• experimental methods and resources (e.g., centers or collaborators)
• unanswered questions
• wish list of future experiments/theory developments

Session 6: Quantum sensing and technological approaches
Chair: Nicole Yunger Halpern — Agent provocateur: Alex Jones
9.50–10.10 am: Michael R. Wasielewski, Northwestern University
Photodriven quantum teleportation of an electron spin state in a covalent system
10.10–10.30 am: Carlos Martino, Florida Institute of Technology
Optimal control in quantum biology: flavoproteins, ROS production, and bioenergetics
10.30–10.50 am: Clarice D. Aiello, UCLA
Quantum sensing techniques as a path towards coherent control in biological systems
10.50–11.10 am: Peter Fierlinger, Technical University of Munich
(TBA)
11.10–11.30 am: Yuval Kolodny, The Hebrew University
Spin dynamics in chiral biological molecules
11.30 am–12.00 pm: Discussion: unresolved issues for the chalkboard (led by Turin and Jones)

• Are ‘living quantum sensors’ harnessing similar quantum effects as technological quantum sensors?
• How can we exploit technology to probe coherent spins in biology?

Session 7: Quantum biology ‘beyond spins’
Chair: Daniel Manzano — Agent provocateur: Margaret Ahmad
1.20–1.40 pm: Nir Keren, The Hebrew University
Do photosynthetic organisms use processes at the quantum-classical border
to tune energy transfer efficiency in their light-harvesting antennae?
1.40–2.00 pm: Justin Caram, UCLA
‘Pathologically’ coherent excitons in molecular aggregates:
when quantum effects are hard to miss
2.00–2.20 pm: Robert Usselman, Florida Institute of Technology
The quantum biology of reactive oxygen species
2.20–2.40 pm: Amartya Banerjee, UCLA
(TBA)
2.40–3.00 pm: Vijay Balasubramanian, University of Pennsylvania (via Zoom)
(TBD)
3.00–3.30 pm: Discussion: unresolved issues for the chalkboard (led by Manzano and Ahmad)
• What new tools do these approaches bring to the table?
• Do these effects depend on spin?, i.e., might there be any overlap with previously discussed effects?

Session 8: The white paper, synthesis
Chair: Clarice D. Aiello, UCLA
A representative of each group presents the group’s lists:

4.00–4.15 pm: Group A ~ biology
4.15–4.30 pm: Group B ~ chemistry
4.30–4.45 pm: Group C ~ physics and engineering

4.45–5.45 pm: Final discussion: next steps to shape the field of coherent spins in biology (led by Ritz)

5.45–6.00 pm: Develop plan for writing schedule and responsibilities (led by Aiello)

Workshop adjournment.