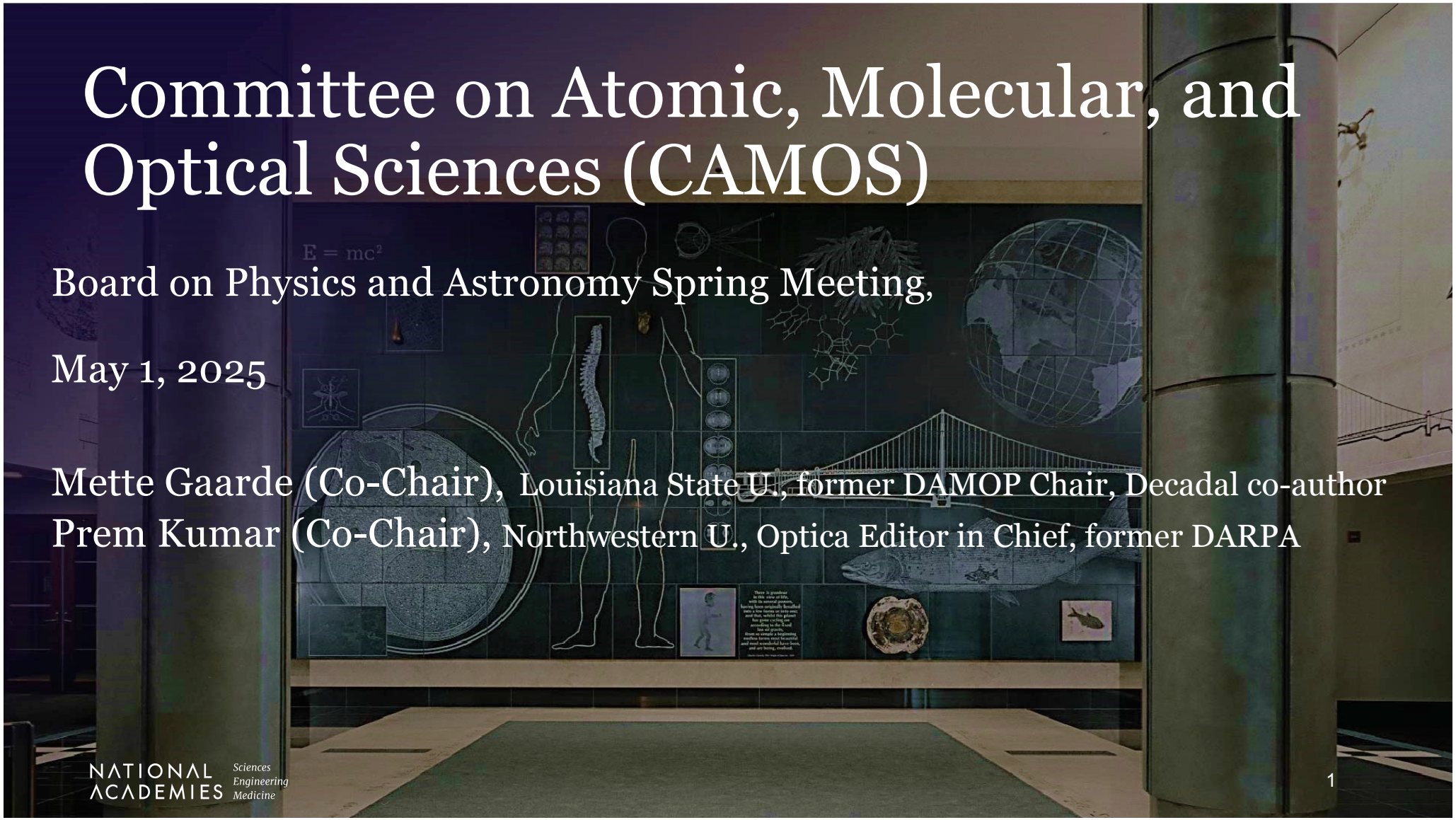
Committee on Atomic, Molecular, and Optical Sciences (CAMOS)



Board on Physics and Astronomy Spring Meeting,

May 1, 2025

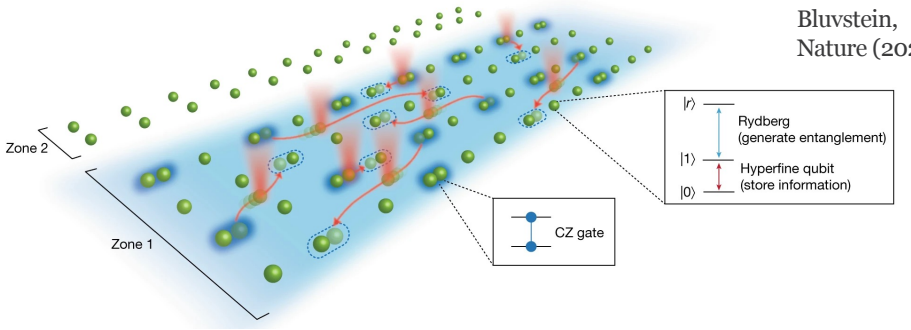
Mette Gaarde (Co-Chair), Louisiana State U., former DAMOP Chair, Decadal co-author
Prem Kumar (Co-Chair), Northwestern U., Optica Editor in Chief, former DARPA

NATIONAL ACADEMIES Sciences Engineering Medicine

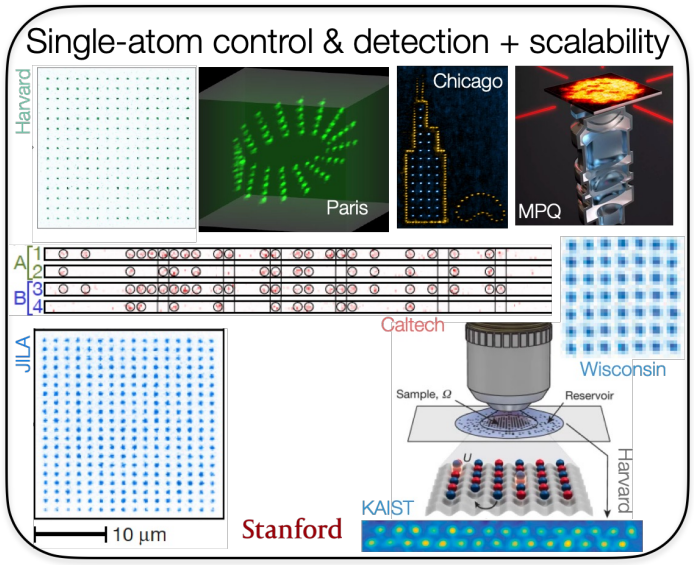
Opportunity: Neutral atom arrays for quantum science

Exquisite laser-based control of

- Spatial location and displacement
- Quantum state
- Interaction/entanglement



Bluvstein, Nature (2022)



Many groups in US
Broad applications in:

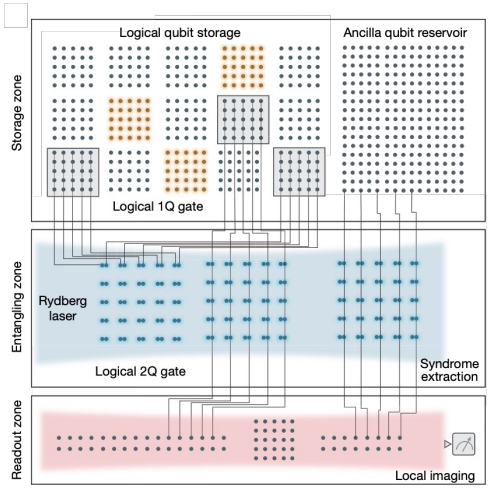
- Quantum computing
- Ultra-stable atomic clocks
- Sensing and Precision Measurements

- Quantum Workforce

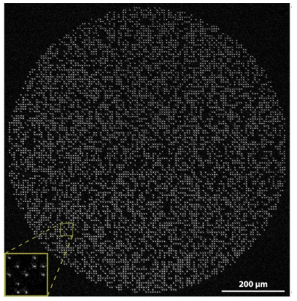
Progress in neutral-atom quantum computing

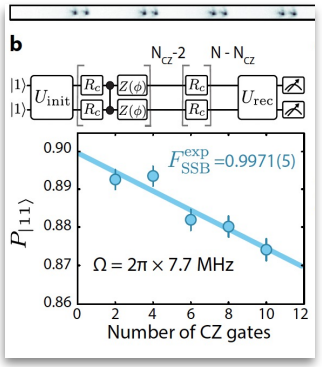
- Programmable connectivity via atom movement
- Quantum circuits with logical qubits and error correction
  Bluvstein et al, Nature (2022) and (2024) (Harvard/QuEra)

- Entangling Zone: Rydberg gates
- Readout zone: fluorescence



- 2-qubit Rydberg blockade gate fidelity: 99.5 - 99.7%
  Evered et al, Nature (2023). Tsai et al, PRX Quantum (2024).
- Mid-circuit measurements for error correction
  Wisconsin, Princeton, Boulder, Caltech, UIUC, UChicago, Atom Computing
- Scaling and continuous loading of >1000-atom arrays
  Manetsch et al (Caltech), arXiv (2024); Gyger et al (MPQ), PRR (2024).





Caltech

CAMOS/BPA meeting intersections

Technology pioneered/developed in AMO community

- Metrology: Optical frequency combs, nuclear clock prospect (Oct 2024)
- Precision Measurements (Oct 2024)
- Attosecond X-ray science (Oct 2024)
- Quantum sensing (May 2025)

Challenge: NIST Atomic Spectroscopy Group is terminated after 120 years

- Atomic databases and tools
  - The only collection of critically evaluated atomic data in the world
  - Unique tools for online calculation of plasma emission
  - Users: astrophysics, astronomy, lithography, fusion science, geology (Earth and Mars), agriculture, archaeology, nonproliferation, atmospheric science…
  - Almost 1,000,000 queries/year
- Precision measurements of spectra and modeling of atomic properties
  - From neutral atoms to 70+-times charged ions
  - New techniques for diagnostics of terrestrial and astrophysical plasmas
  - Lead international efforts on validation and verification of complex models for plasma emission
- Semi-happy ending: picked up by NASA-Goddard/University of Maryland