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Opportunity Title: New and emerging qubit science and technology
Opportunity Reference Code: 1C-18-27

Organization Office of the Director of National Intelligence (ODNI)

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Complete your application – Enter the rest of the information required for the IC Postdoc Program Research Opportunity. The application itself contains detailed instructions for each one of these components: availability, citizenship, transcripts, dissertation abstract, publication and presentation plan, and information about your Research Advisor co-applicant.

Additional information about the IC Postdoctoral Research Fellowship Program is available on the program website located at: https://orau.org/icpostdoc/.

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Description **Research Topic Description, including Problem Statement:**

- Quantum information science and technology has seen steady progress since the motivating algorithmic discoveries of Shor [1] and others. Continued research in qubit science has resulted in the development of several different qubit technologies that can now perform two-qubit operations with less than 1% error per gate with advances toward higher performance and larger qubit systems on the horizon. Simultaneously, quantum systems have been utilized in other applications such as time keeping and sensing often only one qubit is needed allowing for higher temperature operation given the right choice of qubit (e.g., NV centers in diamond). Many advances are needed to push existing technologies toward the distant goal of fault-tolerant quantum computing or systems of similar complexity. This research topic assumes that today's high performance qubits and quantum devices, along with anticipated advances, may not be the same devices on which future technology will be based. This topic seeks explorations of that future technology. Qubits that operate robustly (both alone and via two qubit gates) in "friendlier" environments such as at higher temperatures, pressures, or magnetic fields could enable cheaper, more portable or more scalable quantum devices from repeaters to sensors to quantum computers. New fabrication or growth approaches (e.g., epitaxial devices) may enable solid-state qubits more resilient to charge and flux noise or with preferred geometries. New design approaches (e.g., symmetry-protected quantum circuits or microwave-free control) may offer higher fidelity gates or reduced-overhead quantum operations. Finally, qubit approaches that combine the preferential aspects of superconductors and semiconductor systems may enable new physics which can be taken advantage of or for better qubit technology.

[1] Shor, Peter W., arXiv;quant-ph/9508027 “Polynomial-Time Algorithms for Prime Factorization and Discrete Logarithms on a Quantum Computer.

Example Approaches:

A proposal under this topic could articulate specifics of the novel physical system, advantages over current state-of-the-art qubit systems, technical challenges to matching, and surpassing current best qubit performance and how one would attempt to construct, control, and isolate the novel system. Any proposal for investigation of new qubit systems must robustly address the question of fast and reliable two-qubit interactions (gates).

Proposals could focus on experimental or theoretical aspects of new and emerging qubit science and technology and address one or more of the following questions or goals:

a. New qubits, operating regimes, and environments, such as:

- Symmetry-protected qubits with intrinsic protection from noise
- Qubits that can operate above milli-kelvin temperatures while still allowing for robust two-qubit gates
- New approaches to topologically protected qubits
- New material systems that overcome a primary roadblock to present-day qubits

b. Fundamentally new methods of fabrication, such as:

- Fully epitaxial fabrication techniques that could also enable new types of devices from epitaxial Josephson junctions to superconducting-semiconductor (super-semi) to engineered quantum materials
- Epitaxial and/or ultra-low-loss superconducting Josephson junctions, capacitors, or resonators
- Fully (3D) epitaxial superconducting circuits in silicon or other materials
- Novel methods of fabricating planar semiconductor and superconductor qubits
- New materials for topologically protected qubits

c. New methods of design, control, or operation such as:

- New forms of operation (e.g., universal gate set) for topologically or symmetry protected qubits

- Novel approached to spin qubits (e.g., new encodings) which increase the fidelity of operations or reduce the overhead of classical control
- Superconducting qubits with gate tunable weak-link junctions enabling qubit control via voltage instead of flux
- Superconducting-semiconducting hybrid circuits which enable new physics improving qubit performance

Qualifications

Postdoc Eligibility

- U.S. citizens only
- Ph.D. in a relevant field must be completed before beginning the appointment and within five years of the application deadline
- Proposal must be associated with an accredited U.S. university, college, or U.S. government laboratory
- Eligible candidates may only receive one award from the IC Postdoctoral Research Fellowship Program.

Research Advisor Eligibility

- Must be an employee of an accredited U.S. university, college or U.S. government laboratory
- Are not required to be U.S. citizens

Eligibility Requirements

- **Citizenship:** U.S. Citizen Only
- **Degree:** Doctoral Degree.
- **Discipline(s):**
  - **Chemistry and Materials Sciences** (12)
  - **Communications and Graphics Design** (6)
  - **Computer, Information, and Data Sciences** (16)
  - **Earth and Geosciences** (21)
  - **Engineering** (27)
  - **Environmental and Marine Sciences** (14)
  - **Life Health and Medical Sciences** (45)
  - **Mathematics and Statistics** (10)
  - **Other Non-Science & Engineering** (5)
  - **Physics** (16)
  - **Science & Engineering-related** (1)
  - **Social and Behavioral Sciences** (28)