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Opportunity Title: Control of magnetic ordering for ultra-low power memory and logic
Opportunity Reference Code: ICPD-2019-07

Organization Office of the Director of National Intelligence (ODNI)

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How to Apply **Create and release your Profile on Zintellect** – Postdoctoral applicants must create an account and complete a profile in the on-line application system. **Please note: your resume/CV may not exceed 2 pages.**

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://orise.orau.gov/icpostdoc/index.html.

If you have questions, send an email to ICPostdoc@orau.org. Please include the reference code for this opportunity in your email.

Application Deadline 3/1/2019 6:00:00 PM Eastern Time Zone

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

- The anticipated end of Moore's Law scaling necessitates fundamental research that can lead to devices governed by state variables beyond the charge state variables use in the vast majority of current high performance computing devices. Almost all modern memory and logic devices manipulate the electric charge of electrons. However, as devices get smaller to hold more transistors to process and store ever more data, the amount of power needed to operate these devices increases exponentially and will soon outstrip the world's ability to operate such computers. This is true for Intelligence Community, which relies heavily on computer driven analysis of vast amounts of data. Furthermore, physical limitations on size, speed, and endurance of charge-state devices necessitate entirely new paradigms for computing devices that will allow for necessary growth in computing performance. High risk, high reward applied research leading to novel device designs is essential for the Intelligence Community to mitigate technological surprise and advance the mission of the future. Precise control of magnetic ordering as an alternative state variable, where devices are no longer limited to charge manipulation, has the potential to vastly increase memory efficiency, thereby enabling a new paradigm in ultra-low power computing.

- Previous attempts to employ the low-power control of magnetism by both commercial and academic researchers have focused on piezoelectric strain mediated control of magnetism. However, in all of these cases control has been limited to affecting magnetostriction, carrier charge density, ferromagnetic resonance, or magnetocrystalline anisotropy. Although this offers possible advantages for certain types of devices, it does not accomplish the goal of using intrinsic magnetism as a state variable, and will not lead to devices that offer the orders of magnitude improvements necessary to overcome current device limitations.

- Recently, it was shown that certain materials, for example FeRh, can be controllably toggled from an antiferromagnetic state to a ferromagnetic state using external stimuli. This transitionable magnetic material has been termed "metamagnetic." It was demonstrated that the transition temperature can be precisely controlled using strain, leading to proposals of heterostructure devices of metamagnetic materials on piezoelectric films, whereby the magnetic ordering is controlled by an ultra-low power gate. This is an entirely new and novel device paradigm ideally suited for future high performance computing applications. Creating a logic or memory device that utilizes magnetism as a state variable, such as a metamagnetic device, has the potential for orders of magnitude lower power operation and orders of magnitude higher speed than the state-of-the-art, while offering non-volatility, high endurance, and inherent radiation hardness.

- The goal of this topic is to identify, fabricate, characterize, and fully understand devices that use magnetism as a state variable through control of metamagnetic transitions for future high performance computing applications.

Example Approaches:

- Research to identify new metamagnetic materials that are ideally suited to magnetic state variable device integration using theoretical modeling or experimental measurements
- Research on the fabrication of uniform, device quality metamagnetic materials
- Research to determine how to precisely control magnetism with external stimuli in a computing device (for example with temperature, ion implantation, electric field, light, disorder, etc.)
- Research on fabricating memory and logic devices that utilize magnetism as a state variable
- Research on the nanoscale properties and effects of nanoscale patterning on metamagnetic transitions
- Research to characterize and optimize the performance of novel metamagnetic devices

Relevance to the Intelligence Community:

- A 2015 report for the Semiconductor Industry Association concluded that the energy required to operate the world’s computers will outpace the world’s total energy production before 2040. Moreover, Moore’s Law, the empirical roadmap outlining an exponential increase in computing power, speed, density, and efficiency, is ending imminently due to the physical limitations of current technologies. Therefore, Moore’s law cannot drive future performance upgrades in computing devices.

- It is essential for the Intelligence Community to find new avenues for lower-power, higher-speed, higher performance computing devices. An important component is pursuing avenues of high risk, high reward research at the forefront of the high performance computing devices field, with the potential to deliver a disruptive technology.

- A considerable investment in future computing technologies is critical for the future function of Intelligence Community activities and to prevent technological surprise. The IC must be at the forefront and identify new technologies and help transition and integrate those technologies to ensure the continuity of critical intelligence programs in the future.

Key Words: Magnetic materials, Magnetic memory, Logic, Metamagnetism, Magnetism, Memory, Low-power electronics, High performance computing, Beyond Moore’s Law

Qualifications

Postdoc Eligibility

- U.S. citizens only

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- 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)