

Opportunity Title: 2D materials for ultra-low-power data egress at 4K

Opportunity Reference Code: IC-18-23

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://orau.org/icpostdoc/>.

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

Application Deadline 3/12/2018 11:59:00 PM Eastern Time Zone

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

Cryogenic logic based on superconducting circuits is a promising approach to next generation high performance computing. A primary challenge to a future superconducting data processor is the availability of an energy-efficient high-data-rate interconnect between the superconducting chips at 4K and the room temperature control system. The ideal data egress system would require dissipation of no more than a few tens of attojoules in the 4K environment to convert single flux quantum (SFQ) information into a form that can be transmitted to room temperature. The superconducting system represents digital zeros and ones by either the absence or presence of a SFQ. SFQ circuits produce voltage pulses that are about 1 mV tall and 2 picoseconds wide although this output can be conditioned to make it more suitable for photonic devices. This topic seeks to investigate 2D materials at a fundamental physics level for their promise as energy-efficient high-data-rate electro-optic modulators or other manifestations of data egress devices from 4K. Graphene, for example, has been explored for ultra-low-loss and high bandwidth modulation (e.g., [1]). Newer 2D materials such as molybdenum ditelluride [2] and black phosphorous also show promise in the optical domain. Some of these new 2D materials can be doped directly via electrostatic gating allowing p and n regimes to be created by control pulses, where needed. Such unique properties of 2D materials may enable new functionality of data modulation and communication, especially at cold temperatures.

[1] Phare, Christopher T., Yoon-Ho Daniel Lee, Jaime Cardenas, and Michal Lipson, "Graphene electro-optic modulator with 30 GHz bandwidth", Nature Photonics 9 (2015): 511.



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[2] Ya-Qing Bie, et al., “A MoTe₂-based light-emitting diode and photodetector for silicon photonic integrated circuits”, Nature Nanotechnology, doi: 10.1038/nnano.2017.209.

Example Approaches:

The aim of this research is to experimentally advance the understanding of 2D materials for applications in data communication, particularly energy efficient, high-data-rate communication from a 4K environment to room temperature. Proposals could focus on experimental aspects of 2D materials and their relevance to ultra-low-power data egress at 4K address and one or more of the following questions or goals:

- Can 2D materials offer unique advantages to the creation of energy efficient and high-data-rate electro-optic modulators?
- Can 2D be integrated with silicon photonics and superconducting circuits?
- Does operation at 4K offer new properties which can be taken advantage of? Or, is there a no-go to 4K operation?
- Is there a fundamental limit to the energy per bit in these systems?
- Do any properties of novel 2D materials allow direct transduction of data from SFQ pulses to optical information without the need for pulse conditioning?
- Besides electro-optic modulation, does the physics of a 2D material allow other novel forms of data egress?



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](#) )

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- **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](#) 👁)