

DARPA-EA-24-01-03

QUAntum Materials Engineering using eLEctrOmagnetic fields (QUAMELEON)

I. ARC Opportunity

The Defense Advanced Research Projects Agency (DARPA) Defense Sciences Office (DSO) is issuing an Advanced Research Concepts (ARC) Opportunity, inviting submissions of Abstracts for innovative exploratory research concepts in the technical domain of Physics. This ARC Opportunity, Quantum Materials Engineering using Electromagnetic Fields (QUAMELEON), is issued under the master ARC Exploration Announcement (EA), DARPA-EA-24-01.

ARC Opportunities are designed to allow an individual researcher the opportunity and time to focus on nascent, paradigm-shifting ideas for national security applications. While multiple researchers from the same organization may be proposed, the aggregate level of effort for a proposed research concept must be equivalent to one full-time equivalent (FTE) and 12 months. DARPA expects that the individual(s) working on the proposed idea primarily focus on the effort for the entire period of performance to the maximum extent practical. Only minimal variation to this requirement will be accepted. The maximum period of performance is 12 months. Each ARC award's maximum total value is \$300,000, including direct and indirect costs and graduate student tuition, if applicable. Proposed costs are limited to \$10,000 or less for materials, equipment, and Other Direct Costs (ODC). Under no circumstances will profit be authorized. While resource sharing is not expected, it may be offered in the proposal. Any proposed resource share must be directly applicable to the effort. Any costs proposed beyond the \$300,000 in Government funding will be the performer's responsibility. Travel and publication costs may not be proposed. No subawardees are permitted.

To view the original DARPA Exploration Announcement and the latest amendment issued against Advanced Research Concepts, visit SAM.gov under solicitation number DARPA-EA-24-01: <https://sam.gov/opp/54ba5dd6825d4d84a2468e52e341cdef/view>. It is incumbent upon the proposer to review DARPA-EA-24-01, any resulting amendments to DARPA-EA-24-01, and Frequently Asked Questions (FAQs) before preparing and submitting an Abstract and/or an Oral Proposal Package (OPP) (if invited). All Abstract submissions to this announcement must adhere to the instructions contained in DARPA EA-24-01.

All technical, contractual, and administrative questions regarding this notice must be emailed to QUAMELEON@darpa.mil. This ARC Opportunity is soliciting Abstracts only. DARPA will evaluate Abstracts submitted in response to this ARC Opportunity, as detailed in Section 4 of the latest amendment issued against DARPA-EA-24-01. If the Government selects an Abstract for an Oral Presentation, the Government will issue an invitation to submit an OPP. The invitation will include the submission instructions and deadline.

All awards made as a result of the ARC Opportunity will be Research Other Transactions (OTs) awarded under the authority of 10 U.S.C. § 4021.

Abstracts submitted to this ARC Opportunity will be evaluated on a rolling basis in accordance with the latest amendment issued against DARPA-EA-24-01. The submission period ends four (4) months from release on June 3, 2024 at 4:00 p.m. Eastern Time. No Abstracts will be accepted after the end of the submission period. Proposers are encouraged to submit Abstracts as early as possible. Funding for this ARC Opportunity is limited. Should funding be exhausted, the

Government may elect to shorten the overall submission period with an amendment to this ARC Opportunity.

II. ARC Opportunity Description

Strong light-matter interactions are a key element of many Quantum Information (QI) devices that enable quantum enhanced sensing and information processing. These interactions can be enhanced using optical tools including high finesse cavities, allowing exquisite control of quantum degrees of freedom of individual atoms in the domain of cavity quantum electrodynamics. For example, cavity enhanced light-matter coupling with cold atoms has been used to control photon transport¹ and induce a new supersolid quantum phase of matter.² Applying these precision optical tools to condensed matter systems presents an opportunity to unlock a wide array of optically enhanced materials for QI applications, both in the context of externally driven systems, and systems where the cavity-vacuum directly influences materials properties. Engineered light-matter coupling also has the potential to create or enhance phases of matter including superconductivity, ferroelectricity, magnetism, as well as modify semiconductor exciton physics and topologically ordered systems of interest for QI device applications. Recent insights in solid-state nanophotonics with subwavelength electromagnetic field confinement³ can allow for effects at the vacuum or few-photon level. Of particular interest is the regime of strong light-matter coupling where hybrid systems emerge that inherit useful properties from both their light and matter constituents.

This ARC Opportunity is soliciting ideas to explore the following question: How can engineered light-matter coupling be used to control or enhance quantum materials by harnessing vacuum effects or few-photon external drives?

A. ARC Opportunity Technical Objective

This ARC opportunity seeks to push the boundaries of optical control of solid-state materials, extending established Floquet engineering techniques to regimes where material properties can meaningfully be changed by electromagnetic fields at the few-photon level or by cavity-enhanced vacuum modes, including new phases of matter and out-of-equilibrium effects. Of particular interest are systems where engineered light-matter coupling can be used to enhance or quantify the inter-particle interactions and correlations in a material. Light-matter systems that are externally driven at the few-photon level, as well as systems where materials are coupled to vacuum modes of the electromagnetic field, are within the scope of this ARC topic.

The objective of this ARC topic is to study condensed matter systems where the coherent interaction between light at the few-photon level, or the vacuum electromagnetic field, and matter results in new physics that can be exploited for QI devices such as quantum enhanced sensors, light sources or detectors, transducers, and quantum emulators. Experimental, computational, and

¹ Dayan, Barak, et al. "A photon turnstile dynamically regulated by one atom." *Science* 319.5866 (2008).

² Léonard, Julian, et al. "Supersolid formation in a quantum gas breaking a continuous translational symmetry." *Nature* 543.7643 (2017).

³ Schlawin, Frank, et. al. "Cavity quantum materials." *Applied Physics Reviews* 9.1 (2022).

theoretical efforts will be considered in-scope for the ARC topic. In all cases, performers will justify the relevance of their approach to future devices with capabilities or performance beyond current state of the art.

Currently, there are no specific follow-on acquisition options planned once a performer has completed the effort. However, the goal of this initiative and each selected ARC project is to fund research that may potentially lead to a revolutionary new capability. At the conclusion of the ARC effort, if a performer has demonstrated the potential for additional research and development, the Government may elect to issue a new OT agreement to fund additional tasks to pursue additional research efforts.

B. ARC Abstracts

This ARC Opportunity is intended to be as inclusive as possible; however, proposed ideas should address the appropriate scope, have a clear deliverable at the end of the effort, and include specific practical applications of the research. Abstracts should clearly articulate why their proposed approach is novel and how the results of their research effort could inform or enable the design of future QI devices.

Abstracts should describe a research plan, including (1) detailed intermediate technical objectives with evaluation measures and (2) a schedule segmented monthly or quarterly outlining corresponding deliverables.

DARPA will evaluate Abstracts submitted in response to this ARC Opportunity, as detailed in Section 4 of the latest amendment issued against DARPA-EA-24-01. If the Government selects an Abstract for an Oral Presentation, the Government will issue an invitation to submit an OPP. The invitation will include the submission instructions and deadline.

C. Schedule of Milestones

The specific milestones and due dates listed below are common to all Abstracts and OPPs (see above for technical details and Section III.A. below for additional information on milestones). Abstracts selected to submit an OPP will be required to propose additional milestones associated with the program plan as part of the oral proposal.

- Kick-off meeting: Should define the technical approach and steps going forward.
- Quarterly status meeting: Briefing to include detailed progress towards all research objectives, progress to plan, and discussion of next quarter's objectives.
- Final Milestone: Outbrief to summarize all work completed on the project.

D. Reporting Requirements

Performers will be expected to provide, at a minimum, the following reports:

- Monthly technical updates and financial reports. These reports should include progress to plan and a high-level financial summary.
- Quarterly technical report. Each report should detail progress towards all research objectives and should include a master document that refers to associated explanatory presentation slides, publications, figures, theoretical models, and/or relevant data (e.g., experimental data, numerical simulation, and source code as applicable) with full documentation, as needed.

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- Final technical report. In addition to the executive summary report outlined in DARPA-EA-24-01, this final report should include the final master document from the quarterly technical reports and detailed results of all milestones associated with the program plan for the entire period of performance.

III. ARC Opportunity Submission Format, Instructions, and Selection

A. Abstract Content and Format

All Abstracts submitted in response to this notice must comply with the content and format instructions in Section 3.1 of the latest amendment issued against DARPA-EA-24-01. The submission must use the template provided as an attachment to DARPA-EA-24-01. Abstracts submitted in response to this ARC Opportunity must be unclassified.

B. Abstract and OPP Submission Instructions

Abstracts submitted in response to this ARC Opportunity and OPPs submitted in response to an invitation shall be submitted electronically via the DARPA Submission website at <https://baa.darpa.mil>. See Section 3.3 of the latest amendment issued against DARPA-EA-24-01 for Abstract and OPP submission instructions.

Technical support for the DARPA Submission website is available during regular business hours, Monday – Friday, 9:00 a.m. – 5:00 p.m. Eastern Time. Requests for technical support must be emailed to BAAT_Support@darpa.mil with a copy to QUAMELEON@darpa.mil. Questions regarding submission contents, format, deadlines, etc., should be emailed to QUAMELEON@darpa.mil. Questions/requests for support sent to any other email address may result in delayed/no response.

DARPA will acknowledge receipt of complete submissions via email and assign identifying numbers that should be used in all further correspondence regarding those submissions. If no confirmation is received within two (2) business days, please contact QUAMELEON@darpa.mil to verify receipt.

No Abstracts will be accepted after the end of the overall submission period listed in Section I above. Abstracts must be submitted per the instructions outlined in this ARC Opportunity *and received by DARPA* no later than this time and date. Proposers are advised that the Abstract submission deadline outlined herein is in Eastern Time.

Abstracts will be evaluated and selected in accordance with Section 4 of the latest amendment issued against DARPA-EA-24-01.

IV. Award Information

Selected OPPs will result in a potential award of a Research OT agreement subject to the proposer's acceptance of the terms and conditions. Proposers must review the model Research OT agreement provided as Attachment I to DARPA-EA-24-01.

The completed Task Description Document, Schedule of Milestones and Payments (templates included in Attachment I), and data rights will be included in the Research OT agreement upon award.

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Given the limited funding available for each ARC Opportunity, not all proposals considered selectable may be selected for a potential award.

V. Eligibility

See Section 6 of the latest amendment issued against DARPA-EA-24-01 for information on who may be eligible to respond to this notice.

VI. Human Subject Research

Abstracts to this ARC Opportunity proposing human subjects research will be considered out of scope and may be disregarded.

VII. Administrative Requirements

Section 7.2 of the latest amendment issued against DARPA-EA-24-01 provides information on administrative requirements that may be applicable for proposal submission as well as performance under an award.

VIII. Frequently Asked Questions (FAQs)

All technical, contractual, and administrative questions regarding this notice must be emailed to QUAMELEON@darpa.mil. Emails sent directly to the Program Manager or any other address may result in delayed or no response.

All questions must be in English and must include the name, email address, and telephone number of a point of contact. DARPA will attempt to answer questions publicly in a timely manner; however, questions submitted within seven (7) calendar days of the proposal due date listed herein may not be answered.

DARPA may post an FAQ list under the ARC Opportunity on the DARPA/DSO Opportunities page at (<http://www.darpa.mil/work-with-us/opportunities>). The list will be updated on an ongoing basis until one (1) week prior to the abstract due date. DARPA will also maintain <https://www.darpa.mil/ARC> as a resource page with links to all relevant ARC Opportunities and FAQs.