

HR001123S0052

**Intensity-Squeezed Photonic Integration for Revolutionary Detectors (INSPIRED)
Frequently Asked Questions (FAQ) Document**

As of 10/17/2023

Q1: Figure 1 of the original BAA, and diagrams of squeezed-light interferometers presented at Proposers Day, do not show squeezed light interacting with a sensor. Can you clarify how the squeezed-light detector is expected to operate?

A1: BAA Amendment 1 has been issued to correct Figure 1 and provide additional detail to the required configuration of squeezed-light detector inputs and outputs. Updated Proposers Day slides have been posted to the DARPA website for consistency with BAA Amendment 1.

Q2: Figure 1 of the original BAA includes an optical signal input that appears to be classical. Such a signal can be useful in "calibration mode" for phase control of the interferometer, or calibration of the system without squeezing. For example in "squeezing mode" the internally generated squeezing would combine with the LO (i.e. the signal would be shunted away) and the 16 dB goal would refer to the reduction in the detected noise level that comes from replacing the signal with the squeezing (with same LO power). Would this interpretation be responsive to BAA?

A2: Yes, this configuration is responsive, although not required per the footnote on the volume metric enclosed in BAA Amendment 1.

Q3: Does the squeezed-light detector bandwidth requirement refer to the squeezing bandwidth? How is DC defined as the lower frequency? Does squeezing need to extend to 10 GHz?

A3: BAA Amendment 1 provides revised requirements on bandwidth, with separate performance goals for shot-noise limited output spectrum and for squeezing.

Q4: Is room temperature operation required?

A4: Yes, BAA Amendment 1 clarifies that room temperature operation is required.

Q5: Is pulsed operation allowed?

A5: BAA Amendment 1 clarifies that continuous-wave operation is required.

Q6: My approach needs to use optical wavelengths outside of the operation wavelength requirements in order to make the squeezed-light detector work. Is this responsive?

A6: Yes, other wavelengths of light may be utilized internal to the test articles in order to make them work within the specified operational wavelength bands.

Q7: Can the LO laser be an external benchtop laser?

A7: Yes, the BAA notes that the LO laser can be external to the module and test articles. The BAA does not place any restrictions on LO form factor, power consumption, or performance.

Q8: The power in the LO is not defined in the BAA. Can we assume that LO power on the order of 100 mW is available?

A8: Yes, the LO power may be defined by the proposer. However, the LO power required for a given approach may impact the feasibility evaluation in the Scientific and Technical Merit evaluation criterion.

Q9: Do laser pumps for the squeezed light generator need to be included in the test articles? Can lasers at different wavelengths be external to the module and input through the optical ports to pump nonlinear conversion devices?

A9: BAA Amendment 1 clarifies that the LO may also be used for pumping purposes. If the proposed approach to squeezed-light generation requires nonlinear conversion to generate a different wavelength than the LO, and/or secondary lasers or amplifiers to reach the necessary pump power, then the componentry to achieve those functions should be considered to be part of (and delivered with) the squeezed-light generator in Phase 1, and must be internal to the module (and accounted for in the Volume metric) in Phase 2.

Q10: How does DARPA expect the shot-noise limit to be calibrated? Similarly, how must the squeezing ratio and sensitivity metrics be demonstrated?

A10: The BAA does not dictate the nature of the experimental demonstrations and this is left to proposers to determine as an element of a constructive plan to demonstrate the test articles. Methods that tune LO power to bring measured noise spectra above electronic noise contributions, and/or control the pump power in squeezed-light generators to demonstrate noise reduction, are allowed.

Q11: Does the Squeezing Ratio (SR) metric refer to the ratio of squeezing to shot noise or to the ratio of squeezing to anti-squeezing?

A11: Squeezing Ratio (SR) refers to the ratio of squeezed noise power to non-squeezed noise power (shot noise).

Q12: Does the aggregate optical loss metric include coupling from the squeezed light generator to the interferometer?

A12: The aggregate loss metric does not include coupling loss between the squeezed light generator and the interferometer circuit. However, this loss term will impact Phase 2 when these components are combined into a prototype device.

Q13: Where is the local oscillator power defined?

A13: Local oscillator power is defined as the optical power reaching the interferometer photodiode, which sets the shot-noise floor.

Q14: What is your advice to a proposer who can only meet a subset of the metrics in the table?

A14: Proposals need to address all metrics to be responsive; teaming is encouraged, as stated in the BAA.

Q15: If metrics are met using a technique other than intensity squeezing, would that be considered responsive? Is phase squeezing responsive? Is two-mode squeezing responsive?

A15: All approaches that can meet the program metrics, requirements, and deliverables will be considered.

Q16: Are specific applications of interest for employing INSPIRED technology? What will be the potential commercialization path for this integrated squeezed light detector?

A16: The program is seeking general purpose components for broad application impact. DARPA will continually evaluate specific opportunities to apply and transition the results of the program as it advances.

Q17: Wall-plug efficiency, power consumption, and output power are not program metrics.

A17: While we understand that power consumption, wall-plug efficiency, and output power will have an effect on the eventual use of this technology, they are not a part of the metrics of INSPIRED.

Q16: Are squeezed microwaves a technology of interest.

A16: Squeezed microwaves are not a part of the INSPIRED program. DARPA is always interested in innovative technologies and ideas, and open solicitations are available for non-program abstracts or proposals.

Q18: Are MIT Lincoln Laboratory and Oak Ridge National Laboratory available to team or are they on the government team?

A18: Groups at MIT Lincoln Laboratory and Oak Ridge National Laboratory are involved on the government side of the program as IV&V partners and not eligible for funding through proposals. For proposers wishing to team with other entities at these organizations, it is incumbent on the proposers to provide a sufficient mitigation plan to avoid conflicts of interest.

Q19: Is LIGO a member of the government team?

A19: No.

Q20: If I submit multiple proposals, is there a possibility of being accepted on more than one? Can I be PI or co-PI on multiple proposals?

A20: Yes, an individual or organization may participate in multiple proposals as PI, co-PI, prime, or subcontractor. In this case, proposers should sufficiently differentiate the efforts in distinct proposals, and ensure that proposed labor and materials can be satisfied if all proposals include them are funded.

Q21: We have an application in mind for squeezed light enhanced measurement. Can we describe the application, and may our proposal include tasking to perform a system demonstration by integrating with a device for test?

A21: All proposals must address the specific metrics and requirements of the BAA, which include demonstrating a stand-alone squeezed-light detector component. Proposer concepts for applications may be relevant in proposal sections I: National Security Impact Statement, and J: Vision for Technology Transition and Transfer. Proposers that wish to include additional tasking for system-level demonstrations may do so, but such tasks should be separable from the program-defined work to ensure that partial selections can be made.

Q22: I have an application that requires less squeezing than the program requirement of 16 dB. Can I propose to perform the application in exchange for demonstrating less squeezing?

A22: No, not in the INSPIRED program. DARPA is always interested in innovative technologies and ideas, and open solicitations are available for non-program abstracts or proposals.

Q23: Is there a preference for domestic vs foreign foundries to undertake the development for INSPIRED?

A23: No. The BAA fully describes DARPA's stance for foreign involvement in the program, but does not make place specific requirements on foundries.

Q24: What are the size requirements on Phase 1 test articles?

A24: The BAA requires Phase 1 test articles to be chip scale. There is no chip scale or volume requirement for supporting laboratory test equipment.

Q25: Does DARPA expect to re-organize performer teams moving from Phase 1 to Phase 2?

A25: No.

Q26: Can my approach include routing light on and off chip?

A26: Yes, as long as it meets the performance and volume metrics. The BAA does not place any requirements on keeping light on chip, or even require the use of integrated photonics.

Q27: Will scalable manufacturing capability be considered in proposal evaluations? For example, would electron beam lithography be less preferable?

A27: The BAA does not include specific goals on manufacturability. As one element in the ability to transition technology, manufacturing considerations may be relevant to the "Impact to the DARPA Mission" evaluation criterion.

Q28: Will environmental robustness of proposed approaches be considered in proposal evaluations?

A28: The BAA does not include specific goals on environmental robustness. As one element in the ability to transition technology, tolerance considerations may be relevant to the "Impact to the DARPA Mission" evaluation criterion.

Q29: Do the Phase-1 test articles need to be integrated together in Phase 1?

A29: No, they may be physically distinct and tested separately per the BAA.

Q30: Can the squeezed light and LO be derived from the same laser?

A30: Yes.

Q31: Can foreign entities participate in the program?

A31: Yes, any entity meeting the eligibility requirements of the BAA may propose.

Q32: Will supply-chain issues for thin-film lithium niobate be a factor in proposal evaluations?

A32: No.

Q33: Are there any ITAR considerations for the program?

A33: No, DARPA has not identified ITAR concerns for INSPIRED

Q34: How is the volume metric defined? Can chips and components with sum volume less than 100 cc be integrated on a larger-than-100 cc breakout board?

A34: The volume metric applies to a module including the internal componentry and input/output ports specified in the BAA. If the module interfaces with a breakout board with the required electrical ports, then the breakout board should be considered an external test component and does not count towards the volume metric.

Q35: Is a particular sensing quadrature preferred for employing INSPIRED detectors?

A35: The Phase 1 interferometer circuit test article must be able to lock to any quadrature so that INSPIRED detectors may interface with general optical systems after the program.

Q36: Are alternative types of interferometers to homodyne responsive?

A36: Yes, the BAA notes that alternative detection methods will be considered as long as they meet program metrics.

Q37: Does the operation wavelength requirement apply to the spectral band of the detector or to spectral precision?

A37: Spectral band.

Q38: Can we demonstrate the 10 GHz detector bandwidth at a higher RF center frequency, for example from 100-110 GHz?

A38: No.

Q39: I expect to measure insertion loss in the Interferometer Circuit by fiber-coupled input/output power measurements. Do fiber-to-chip coupling losses count towards the Aggregate Optical Loss metric?

A39: The Phase 1 Aggregate Optical Loss metric only includes those losses within the Interferometer Circuit test article itself, so in this case, fiber-to-chip coupling losses should be calibrated out of the measurement(s).

Q40: The BAA calls for the detector to be shot-noise limited up to 10GHz. Can you clarify what is meant by "shot-noise limited"? My interpretation is that the measured variance on a spectrum analyzer at 10GHz sideband, in the absence of any LO light or signal (i.e., dark noise), should be equal to the contribution from shot noise in the presence of LO light. That is, "At least 3dB of dark noise clearance up to 10GHz, and as much is necessary below that to enable 16dB of squeezing measured at the selected squeezing sideband." Is that correct?

A40: Yes.

Q41: Referring to Fig. 1 under Section 1.D. from BAA Amendment 01, along with Q&A #9, my interpretation is that the LO has to be the pump. Therefore, "LO and pump" in the picture above does not mean two separate lasers, but instead that the LO is both the LO and the pump, e.g., a single laser. Is this the correct interpretation?

A41: Yes.