

Department of the Navy SBIR/STTR Transition Program

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ONR Approval #43-8742-21

Topic # N192-126

A Chip-based Orbital Angular Momentum Receiver for Underwater Optical Communications

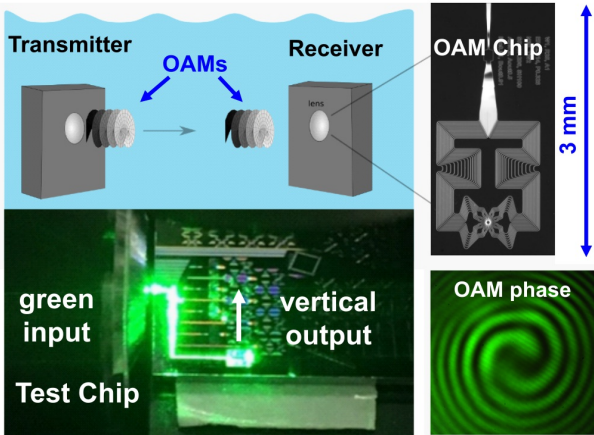
Physical Sciences Inc.

WHO

SYSCOM: ONR
Sponsoring Program: ONR-321
Transition Target: PMS 495, PMS 406, and PMS 408

TPOC:
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Other transition opportunities: Oil and gas industry

Notes: Underwater orbital angular momentum (OAM) transmission uses beams of light with twisted phase fronts that have been shown to transmit through turbid water more efficiently than beams with flat phase (top left). To deploy this technology the Navy requires a low-SWaP approach to transmitting and receiving OAMs. PSI has realized a highly compact chip-based OAM transceiver (top right). We have successfully demonstrated these chips using green light (bottom left) and have shown their ability to generate OAMs (bottom right).



Chip-based OAM Transceiver (Copyright 2021, Physical Sciences, Inc.)

WHAT

Operational Need and Improvement: A high-bandwidth underwater optical link is a critical need for underwater communications. An ideal underwater communications link should be compact and robust, capable of high bandwidths with low error-rates and crosstalk to establish a secure link over long distances. An optical communication system is a highly attractive solution as RF is unable to penetrate water and acoustic systems are low-bandwidth. The large bandwidths and high directionality of laser- based systems are a promising alternative, however, Gaussian beam systems suffer from scattering due to turbidity. Light carrying orbital angular momentum (OAMs) experimentally exhibit higher transmission in simulated turbid water.

Specifications Required:

- For 100 m scale operation: bandwidth 10 Mbps
- For several meter link distance: bandwidth 1 Gbps

Technology Developed: A low-SWaP, high-bandwidth optical transceiver

- OAM states increase operational distance and bandwidth through multiplexing
- Photonic-integrated circuit operating at blue/green wavelengths reduces size
- Scalable fabrication approach reduces cost

Warfighter Value: A high-bandwidth, long-range underwater communication system is a game-changing capability for the Navy. For example, sensor data collected by a UUV could be quickly and securely transmitted without requiring the UUV to return to a ship or to surface. Such a communication system can be used to remote control UUVs operating in dangerous environment with real-time feedback including video and sensor data. Furthermore, low-SWaP OAM transceivers can be placed on multiple UUVs to enable reconfigurable underwater networks and could also be used to conduct coordinated swarm operations.

WHEN

Contract Number: N68335-21-C-0072 Ending on: December 5, 2022

Milestone	Risk Level	Measure of Success	Ending TRL	Date
OAM generation using visible light	N/A	Measurement of phase front using visible light interferometry.	3	2nd QTR FY21
Free-space receiving of OAM states	Low	Transmission of OAM data from a free-space source to the OAM chip with low crosstalk.	3	1st QTR FY22
Operation in a simulated underwater environment	Med	Successful transmission of data over an OAM channel through simulated turbid water.	4	2nd QTR FY22
Packaged OAM transmitter	Low	Develop a fully packaged prototype transmitter head.	4	1st QTR FY23

HOW

Projected Business Model: Physical Sciences Inc. (PSI) plans to create two product variants for initial commercialization. The first product is a green wavelength OAM photonic integrated circuit that would be sold to underwater communications equipment suppliers for integration in their systems. Second, PSI will also directly market its own version of an underwater communication link, including transmitter and receiver terminals with integrated optics, lasers, detectors, and electronics, directly to end users.

Company Objectives: PSI develops advanced technologies and products for the military, aerospace, industrial process, energy, telecommunications, environmental, and medical markets. PSI is strongly committed to developing products based on innovative technologies developed under the SBIR program and has successfully transitioned numerous technologies to support the missions of the Department of Defense, NASA, EPA, and many commercial partners throughout the entire history of the SBIR program.

For this technology, we plan to identify near-term adopters to define CONOPS scenarios and derive technical requirements.

Potential Commercial Applications: Oil and gas companies that perform undersea exploration use UUVs to survey new and current installations. Initially, prototype transceiver systems will be dedicated to military users, but in parallel, we will market early prototypes to oil and gas industry, UUV manufacturers, and undersea-exploration companies.

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