Proposal Title:

"Multiple Structured Electromagnetic Waves Containing Orbital Angular Momentum for Novel Communications, Imaging, and Directed Energy"

ABSTRACT

Beams of light, indeed all electromagnetic waves, can carry orbital angular momentum (OAM). An OAM beam is uniquely structured, such that the spatial phase front "twists" in a helical fashion as it propagates, and different rates of phase change form a set of orthogonal modes.

Utilizing multiple EM waves with different OAM values has been relatively unexplored, with a rich set of basic research challenges that has the potential to dramatically impact multiple DoD disciplines. Each different OAM beam has a uniquely structured phase front and a central intensity null that are sensitive to disruption by interacting with each other and with matter. We will explore using multiple OAM beams: (i) simultaneously for capacity/local power gain from multiplexing, or (ii) sequentially for diversity gain using multiple unique measurements. If successful, new knowledge and >10X performance enhancements will be achieved.

Our curiosity-driven and focused scientific study includes: (i) mechanisms for minimizing and maximizing the linear and nonlinear interactions among beams and with different types of matter (air, objects, sub-wavelength structures); and (ii) dependencies of OAM modal structures under harsh conditions. We will investigate: (a) the complex OAM spectrum; (b) interaction of structured beams with matter; (c) temporal/spatial characterization in nonlinear media, and (d) extraction/quantification of OAM signatures produced during interaction. We will explore tailoring of the beams' structure and methods for signature analysis/recovery.

We will examine proof-of-concept capabilities, including: (a) Communications: Capacity can be multiplied by simultaneously transmitting multiple beams, and the beams' can be tailored to limit eavesdropping. (b) Imaging: multiple structured beams can improve measurement sensitivity to sub-diffraction-limited resolution, and (c) Directed energy: different modes can be combined coherently to form spatial patterns with localized >10X intensity gain.