1. **Research Title:** Engineering Photonic Materials Using Exceptional Points
2. **Individual Sponsor:**

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3. **Academic Area/Field and Education Level:** Electrical Engineering, Optical Sciences, Electro-Optics, or Physics (MS or PhD level)
4. **Objectives:** Using a deep understanding of exceptional points to develop techniques to enhance and optimize the nonlinear interaction for integrated photonics applications. Optimization will include modal interaction with nonlinear materials, group velocity, bandwidth, and spectral separation from other resonant behaviors.
5. **Description:** Enhanced light-matter interactions are critical to extend material and device behavior to "generation-after-next" systems, where natural materials (nonlinearity, gain, etc.) are unable to meet performance. This DAGSI topic will explore the novel concept of using slow light phenomena associated with third-order exceptional points (EP) in optical waveguides for possible cavity-less lasers applications. The goal is to set the canon for future concepts such as cavity-less lasers with robust oscillation performance, power efficiency, and high-brightness characteristics. The third order EP under investigation goes also under the name of stationary inflection point (SIP) or frozen mode regime, which is a regime of operation associated with vanishing group velocity. For frequencies close to the SIP (higher and lower), the waveguide supports a mode with positive group velocities only, which is completely different from other degeneracy points. We will investigate how these new concepts can be used to design cavities based on the frozen mode regime that exhibits high density of states despite the low quality factor, and how this condition affects the lasing regime. Additional advantages of the SIP regime include a tolerance to structural imperfections and losses in photonic structures supporting the frozen mode regime, as compared to common cavity resonances. The proposed approach is scalable and able to be tailored to any frequency range, from microwave to optical frequencies. In this project we focus on investigating lasers based on the frozen mode regime at optical frequencies (1 - 2 um) and even longer wavelengths in the mid infrared region for a variety of DAF applications. The findings will be useful also to pave the way for the next step that would be the investigation of unidirectional lasing when using magneto-optic materials to break reciprocity.
6. **Research Classification/Restrictions:** Not classified. Only US Citizens will be considered.
7. **Eligible Research Institutions:** All