OVPR Seed Grant Abstract

Building Quantum transducers at GHz to IR frequencies using topological materials

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At the core of quantum measurements and information processing is the transduction of information from one physical modality to another. This is extremely important since these modalities often operate at different frequencies. For example, it is often the case to create or decipher a quantum entanglement at one frequency (e.g. GHz) and transfer the quantum carriers long-distance using another frequency (e.g. IR). Therefore, a transducer workable at all frequencies would naturally be the most desirable one. Although several candidate quantum systems have emerged in recent years, to date, there is none that can operate at full-spectrum. *Thus, our goal in this SEED proposal is to initiate a new platform and experimental proof of principle of a full spectrum (GHz-THz-IR) transducer enabled by the topological effects in quantum materials.* Such a transducer would be revolutionary having the capability of generation, transduction (high fidelity down-conversion and up-conversion), and coherent control of the chiral electromagnetic waves at GHz to UV frequency ranges. This is achieved by utilizing the intrinsic chiral (topological) properties in materials, e.g. Dirac/Weyl materials or graphene, without invoking traditional methods such as waveplates, polarizers, or other low-efficiency nonlinear crystals or optics. In quantum communication, chirality would function as an encoder and a decoder for a transmitted message, as well as a "quantum bus" between modalities. We will address this challenge by theory/computation guided designing, synthesizing, and tuning of topological materials with the goal of increasing the carrier relaxation time above microsecond in conjunction with experimental [Liu, Du] and theoretical [Kharzeev, Cano] investigation of chirality flipping mechanism in topological materials. The funds from the OVPR SEED grant will be used to support one to two graduate students and purchase necessary materials for fabricating the transducers. The students will be in charge of communicating among different groups and performing the proof-of-principle experiments at Liu and Du's lab. The PIs and students will be meeting and discussing the experimental and theoretical progress on a weekly bases. This OVPR Seed Grant would allow the PIs to work with their collaborators on initial results which will facilitate at least three incoming grant applications in DOE and NSF.