MUREP Small Business Technology Transfer (M-STTR) Planning Grants

Title: **Development of advanced APbX3 (APX) perovskites as room temperature semiconductor detectors for neutron and gamma radiation detectors**
Institution: Fisk University
City/State: Nashville, TN
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SUMMARY: Gamma-ray and other ionizing detection is an important technology in support of future high-priority science missions, Such as space-based X- and gamma-ray observatories that promise to deliver fresh insights into the processes of particle acceleration by active galactic nuclei (AGN), for in situ investigations of the chemical makeup of planet and asteroid surfaces and in recent years in the area of multi-messenger astronomy (MMA) in the search of high energy gamma-ray counterparts for gravitational wave events.

Within the past years, we have discovered several bright new crystals including LiInSe2 that was the first Li-based semiconductor and a number of rare-earth halide scintillator crystals that have outstanding energy resolution due to their high light output and improved energy-deposit-to-light linearity, and thus they can substantially enhance the performance for the next generation missions for hard x-ray, gamma-ray, and neutron astrophysics or planetary science. The crystals we are targeting show good cross-section for thermal and fast neutrons and very high light yields of up to 120,000 photons/MeV, low cost, and with potential energy resolutions as good as 1% at 662 keV. Perovskite are a fast-emerging family of materials with the best known being CsPbBr3 that show the promise of being a low cost and effective detector are investigated by a number of academic institutions world-wide. As an alternative to PMTs, silicon photomultipliers (SiPM) have generated enormous interest for a number of photo-sensing applications. The unique combination of a high light output scintillator with a high efficiency photodetector should deliver excellent energy resolution in low power, compact, and low weight systems such as the ones using the CubeSat platform that was recently demonstrated in our labs. For many years, it has been recognized that bulk crystal growth and purity of the detector material the key to the successful production of reliable radiation detectors. Scintillation crystals are now routinely grown in small sizes at Fisk University for use as gamma-ray detectors which are used for national security applications. Recently, Fisk and XI partnership developed several advanced Tl-based wide gap semiconductors and scintillators together with other groups worldwide. In the M-STTR Fisk/XI partnership we propose will build upon extant infrastructure and expertise in material development, applying materials research to design, fabricate, and characterize astrophysical detectors, assemblies, and instruments.

The PI along with Co-I will be responsible for conducting all the project scientific and management reporting duties. The research plan includes weekly meetings of the participants, and the research tasks and deliverables of the partners will be clearly defined. The research will focus on material engineering, crystal growth and ceramics processing (to be performed at XI) and characterization, detector fabrication and testing (to be performed at Fisk) of novel APbX3 (APX) perovskites where A=Li or Tl and X=Br or Cl. By the end of the 4-month M-STTR project we will be able to not just assess the merits of this family of compounds but also identify the best mode of operation (semiconducting or scintillating) that might be best to pursue in the future. Our team has the needed expertise and infrastructure for the execution of this component of the project that will have an excellent chance of advancing the competitiveness of our team in the future mainstream SBIR/STTR competitions.