0.1 Project Summary: Solicitation 22-586

Title: Translation of Machine Learning and Additive Manufacturing to Accelerate and Diversify Science and Engineering

Radio-frequency (RF) phased-array systems optimized with machine learning have become powerful tools in science and engineering. Recent progress in phased-array radar development has applications in particle astrophysics [?, ?, ?, ?], polar research [?, ?], and 5G mobile communications [?]. Phased-arrays are comprised of RF antennas working in tandem to boost received signal sensitivity, and to actively scan transmitted signals without moving parts. There are at least two barriers that impede phased-arrays from enhancing future science and engineering projects on a wide scale. First, the computational electromagnetism (CEM) properties of RF systems are designed with expensive, proprietary software that does not interface with common machine learning software. Second, RF systems are manufactured using standard machine tools, which drives up costs.

We propose to create an open-source CEM and additive manufacturing ecosystem capable of 3D-printing phased array systems with conductive filament, following recent efforts in 3D printing single-element RF antennas and open-source CEM development [?, ?, ?]. We have already demonstrated that open-source CEM tools can drive the phased-array design process [?, ?, ?]. This research will reduce costs, boost performance, and lower barriers to entry in diverse applications ranging from IceCube Gen2 (radio), Center for Remote Sensing and Systems (CReSIS) missions, and Office of Naval Research (ONR) radar projects. One key example is the Askaryan Radio Array (ARA), in which phased arrays will be responsible for sensitivity gains to cosmogenic and astrophysical ultra high-energy neutrinos (UHE-ν) [?]. The societal impact of this research is to fundamentally success across multiple disciplines. We are therefore proposing to develop an educational program designed to *translate* successes in materials research and CEM into successes in diverse fields that rely on phased arrays as the primary instrument.

Whittier College is a Title-V Hispanic Serving Institution (HSI), with a proud tradition of providing access to higher education to Spanish-speaking and traditionally under-represented students in Southern California and beyond. Seventy percent of our undergraduates are people of color, and forty percent are first-generation students. Studies conducted by our Bayard Rustin Fellows indicate that our diverse students experience a variety of difficulties in introductory STEM courses. Disparities in introductory STEM courses is a well-known and complex problem [?]. Further, we have learned from workshops hosted by the Cottrell Scholars Network that emphasizing student dignity and self-efficacy can increase the performance of diverse undergraduates in our courses [?, ?]. These topics engage students in a way that makes them feel they will belong and thrive in our courses. Within this context, we propose to create a free, bilingual (Spanish and English) mobile application that introduces STEM concepts within a digital environment that welcomes our students. Our application will self-adapt to individual students using machine learning techniques, and provide insights to optimize instructor performance, based on precedent from educational datamining (EDM) literature [?, ?, ?, ?]. Members of our community have shared anecdotal evidence that translating mathematics exercises into Spanish helps them solve them. Our application would welcome such students by presenting new exercises in their first language.

We also propose two new bilingual lecture series. First, we propose to create a bilingual physics lecture series, hosted at Whittier College and other community venues, that presents physics research to bilingual audiences. Second, we propose a series of bilingual undergraduate engineering recruitment events designed to welcome new students and their families into our learning and research community.