**NRT-IGE: Enhancing Learning and Retention in Graduate Physics**

**Overview:** Graduate core courses in physics are a critical and deeply traditional part of graduate physics education, and as such, can present a significant barrier to obtaining a Ph.D. in physics and inhibit much-needed diversity in the field. The overall goal of this project is to improve learning, retention, and the student experience for graduate physics students enrolled in the core graduate courses in order to better prepare a diverse population of students for graduate research, obtaining a PhD, and pursuing a productive STEM career. The project is especially aimed at helping students who tend to be somewhat underprepared and/or are from underrepresented groups, such as women or African American, Hispanic American, and Native American students. The project includes 4 large public Universities from three states, and the team includes experts in physics education research and faculty learning communities, graduate faculty instructors from all four participating institutions, and a faculty administrator with experience establishing a Master’s-to-PhD bridge program for underrepresented physics students. The approach applies and adapts a successful model for establishing and maintaining faculty learning communities to facilitate the professional development of instructors and the adoption of research-based instructional materials and best practices. The project will also engage the department graduate studies committees of each institution to facilitate positive change in core course policies and practices in order to ensure systemic and lasting change. In a bottom-up process emerging from the needs of the faculty learning communities, instructional materials will be developed via a highly effective research-based iterative model including the identification of student difficulties and construction of materials to engage students in addressing those difficulties in an inclusive and welcoming environment. The materials developed apply to core course topics that are standard to most graduate physics programs in the nation. This project is novel for employing these research-based methods at the graduate level, where little-to-no work has been done. The approach includes formative and summative feedback via performance on content tests, course tests and assignments, in-class performance, student surveys (e.g., attitude, belonging, motivation) and student and faculty surveys and interviews.

**Intellectual Merit:** This program will advance our knowledge on how to improve learning and retention in physics graduate programs, with special attention paid to studying and addressing factors affecting diversity. The program may also serve as a model for other STEM graduate programs with similar issues with graduate core courses. Further, this program will advance our knowledge of topic-specific instructional materials and methods to improve student learning at the graduate level, which is currently virtually non-existent. A rich collection of specific materials will be developed that address specific student difficulties at the graduate level.

**Broader Impacts:** This project has five broader impacts. First, this project will help to improve the diversity of students obtaining a physics PhD. This includes women and other underrepresented groups. Second, the development and adoption of instructional best practices in core courses will improve STEM learning for all students in the graduate physics program, thus better preparing a population of students for STEM research and STEM careers. Third this project will increase the educational skills and expertise of graduate level instructors. Fourth, this project will make permanent, systemic improvements to graduate physics education in 4 large Universities and potentially at the national level. Fifth, this project will engage 4-6 institutions in the adoption and further development of effective, research-based instructional materials and methods for common physics graduate core courses. Further these materials will be made publicly available for adoption nationally, if not world-wide, at other institutions.