**[ORIGINAL]**

## Studies of the physical and thermodynamic properties of dusty plasmas and plasma crystals

The application of the plasma sciences has grown rapidly over the past decade. In applications as diverse as the plasma processing of materials to the interaction of near-earth orbiting satellites with space plasmas, there is an increasing demand for a better understanding of the plasma state of matter. Of particular scientific and technological importance is the behavior of particulate matter in plasmas. These "dust" particles can not only be a source of contamination, but can also change the properties of the plasma. In this proposed five-year CAREER project, new laser diagnostic techniques will be used to investigate the electrical, physical, and thermodynamic properties of dusty plasmas. These investigations will serve as a backdrop from which to broaden the study of electricity, magnetism, and optics for local high school teachers and high school students.

At Fisk University, a new plasma device, the Fisk Plasma Source (FPS) has recently become operational with start-up funds provided through the Physics Department. The scientific component of this project will focus on dusty plasma systems produced in FPS. Initial investigations involve the study of dust particle transport in the plasma. This will be accomplished by using Mie scattered light from dust particles suspended in the plasma. A relatively new technique, particle image velocimetry (PIV) - previously used on fluid systems, but not on dusty plasma systems, will be used to obtain direct measurements of both the position and the velocity of the dust particles in the plasma.

Later studies, in the third through fifth years, will focus on static arrangements of dust particles in the plasma, so-called dust or plasma crystals. Using the PIV techniques while making perturbations to plasma parameters will allow measurements of both the "crystal" properties of these arrangements as well as the thermodynamic properties of the plasma crystals. By making observations of phase transitions, measurements of the heat capacity and latent heat of the plasma crystals, it will be possible to quantify the state function for the thermodynamic state of the crystal.

These studies of dusty plasmas involve many fundamental principles in physics. Thus, this project can provide a strong link between classroom studies at the high school level and the work done in a professional laboratory. A competitive program will be established, as part of this project, to bring a high school student/teacher pair to the laboratory each summer. The team would propose a demonstration project, based in electromagnetism and optics, that could be developed over the summer and taken back to the classroom during the follow academic year. The team would also participate in the laboratory research activities during the summer. During the academic year, the PI would also serve as "science mentor" for the teacher's physics class providing technical, educational, and some equipment support. In this manner, long-term links will be established between the university and local schools, students will be exposed to the work of professional researchers, and a pipeline can be established to encourage students to pursue careers in the sciences.

**[REWRITE]**

**CAREER: Studies of the physical and thermodynamic properties of dusty plasmas and plasma crystals**

The application of the plasma sciences has grown rapidly over the past decade. In applications as diverse as the plasma processing of materials to the interaction of near-earth orbiting satellites with space plasmas, there is an increasing demand for a better understanding of the plasma state of matter. Of particular scientific and technological importance is the behavior of particulate matter in plasmas. These "dust" particles are not only a source of contamination, but can also change the properties of the plasma. In this proposed five-year CAREER project a new laser diagnostic technique – Particle Image Velocimetry (PIV) will be used for the first time to make direct measurements of particle transport in dusty plasma. From the transport measurements and associated velocity distributions, it will be possible to investigate the electrical, physical, and thermodynamic properties of dusty plasmas. These investigations will serve as a backdrop from which to broaden the study of electricity, magnetism, and optics for local high school teachers and high school students.

**Intellectual Merit**: The scientific component of this project will focus on dusty plasma systems produced in FPS. Initial investigations involve the study of dust particle transport in the plasma. This will be accomplished by using Mie scattered light from dust particles suspended in the plasma. A relatively new technique, PIV - previously used on fluid systems, but not on dusty plasma systems, will be used to obtain direct measurements of both the position and the velocity of the dust particles in the plasma. Later studies, in the third through fifth years, will focus on static arrangements of dust particles in the plasma, so-called dust or plasma crystals. Using the PIV techniques while making perturbations to plasma parameters will allow measurements of both the "crystal" properties of these arrangements as well as the thermodynamic properties of the plasma crystals. By making observations of phase transitions, measurements of the heat capacity and latent heat of the plasma crystals, it will be possible to quantify the state function for the thermodynamic state of the crystal.

**Integration of Research and Education**: The study of dusty plasmas involves many fundamental principles in physics such as electromagnetism, classical mechanics, and optics that are often challenging to the high school physics curriculum. This project can provide a strong link between classroom studies at the high school level and the work done in a professional laboratory. A competitive program will be established, as part of this project, to bring a high school student/teacher pair to the laboratory each summer. The team would propose a demonstration project, based in electromagnetism and optics, that could be developed over the summer and taken back to the classroom during the following academic year. The team would also participate in the laboratory research activities during the summer. During the academic year, the PI would also serve as "science mentor" for the teacher's physics class providing technical, educational, and some equipment support. In this manner, long-term links will be established between the university and local schools, students will be exposed to the work of professional researchers, and a pipeline can be established to encourage students to pursue careers in the sciences.

**Broader Impact:** This integrated CAREER project will not only advance new diagnostic tools for the study of plasma science, but also has the opportunity to explore a topic of dusty plasma research that has yet to be extensively investigated. Because charged microparticles are present in so many plasma environments – from industrial to space plasmas – understanding how these particles are confined and transported through the plasma will contribute to many aspects of plasma physics research. Finally, through its close integration of research opportunities for high school teachers and students this project enhances the teaching and learning of advanced topics in high school physics.