Physics Motivation and Goals

Dusty plasmas are plasmas containing small (nanometer to micron sized) solid charged particles. The study of these plasmas has grown dramatically over the last 15 years. Dusty plasmas occur naturally in myriad space and astrophysical environments (e.g. star-formation regions, planetary atmospheres and rings, comets, interplanetary and interstellar media) and are being actively investigated in the laboratory. Dedicated experiments are being conducted worldwide to study basic issues such as dust grain charging, wave behavior, dust dynamics and transport. Further, the formation in the laboratory of novel crystallized dusty plasmas ("plasma crystals") in the mid-nineties has led to exciting new investigations of phenomena in strongly coupled plasmas that have overlap with generic processes in condensed matter. Because the dust can be directly imaged, processes such as wave behavior and phase transitions can be studied at the kinetic level. Dust also plays an important role in technological plasma applications such as those associated with etching processes in microelectronics and new applications such as the fabrication of thin films and tailored particles. Recently the importance of understanding the effects of dust on fusion safety and plasma performance has emerged.

In spite of all the advancements in this field in such a short time, research has only scratched the surface of this exciting new area of plasma physics. Most dusty plasma experiments up to now do not have an external magnetic field, although magnetic fields are pervasive in dusty plasmas in the cosmos and occur in laboratory plasmas where dust is observed such as tokamaks. There is also a significant amount of theory that has been developed over the last decade on the physics of dust in plasmas in magnetic fields. The goal of this project is to build a device to study the physics of dusty plasmas in it most general state, with an external magnetic field, to investigate physics issues hitherto inaccessible in the laboratory. This device would enable a progression of studies in parameter ranges and magnetic field strengths where first the electrons are magnetized, then the ions are magnetized, and finally the heavy dust is magnetized. A variable external magnetic field would also enable novel studies with magnetic and paramagnetic particles in plasmas, similar to magnetic colloids but with the dynamics having much shorter times scales and much less damping.