A New Planetary Material Characterization Facility for Physical Properties of Planetary Materials

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The fields of planetary science have seen tremendous growth in the past few decades. Within the Solar System, the Cassini-Huygens mission conducted a grand tour of the Saturnian system for 13 years, in particular, exploring Saturn's enigmatic moon, Titan. The New Horizons mission explored the farthest former planet (Pluto) in the Solar System and a Kuiper Belt Object, Arrokoth. In the next couple of decades, we will go beyond orbiters and landers - NASA's Dragonfly mission will explore the surface of Titan through a rotorcraft lander in the 2030s [1], and various sample return missions are bringing extraterrestrial samples back to Earth from asteroids, Mars [2-4], which opens unprecedented pathways to explore materials beyond what we have on Earth.

Planetary materials are essential components to understanding various processes on planetary bodies. Many planetary atmospheric, surface, and interior processes are the results of a combination of the dynamical environments and the properties of the local planetary material. As an example, most of the existing and planned sample returns come from small airless bodies, where environmental-induced forces (gravitational force, wind-induced drag force) typically remain weak, due to the weak gravity and minimal atmospheric pressure. Thus, the interparticle forces dominate over these environmental-induced forces on small airless bodies, and the interparticle forces are heavily affected by the material properties of the surface sediments. This underscores the importance of characterizing various material properties that would shape the force environment of sediments on small bodies. The increasing amount of space missions that perform in-situ measurements (landers, rovers, and drones) and return samples to Earth for analysis allows us to have access to a range of important intrinsic properties of planetary materials.

My previous works have focused on characterizing the material properties of organic materials that possibly exist on Titan, using a range of simple organics and the complex Titan aerosol-analog organics that are simulated in the laboratory (or the so-called "tholins") [5-8]. The unique material surface, mechanical, and electrical properties of the Titan organics have shown that a range of atmospheric processes, such as cloud formation and surface processes, such as sediment transport and rain-lake interactions, operate differently compared to Earth. As a new assistant professor at UT San Antonio, our group is building a new laboratory facility – a Planetary Material CHaractErization Facility (PMCHEF) that would enable a range of physical property characterization. The instrumentation of PMCHEF will include nanoindentation for mechanical properties, atomic force microscopy for surface and electrical properties, and ellipsometry for optical properties from the UV to the mid-IR. All the instrumentation of PMCHEF will be housed in moisture- and oxygen-free dry nitrogen glove boxes to prevent degradation and contamination of planetary material in the ambient atmosphere. We intend to have this facility dedicated to the measurement of a range of planetary materials, including planetary aerosol analogs, field samples, meteorites, planetary regolith analogs, and potentially return samples from existing and upcoming sample return missions. Because of the small amount of available returned samples, these nanoscale and single-grain level measurements would be the most suitable techniques to characterize their material properties. The controlled environment will also better mimic the moisture-free and oxygen-free extraterrestrial environments.

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