National Aeronautics and Space Administration
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Cleveland, Ohio

COLLisions Into Dust Experiment-2 (COLLIDE–2)

Introduction

The COLLisions Into Dust Experiment-2 (COLLIDE–2) is scheduled to launch on Space Shuttle Endeavour mission STS–108. The purpose of COLLIDE–2 is to understand the physics of low-energy collisions in planetary rings and protoplanetary disks and to provide experimental constraints on models of planet formation and planetary ring origin and evolution. The experiment was designed and manufactured by students at the University of Colorado, Laboratory for Atmospheric and Space Physics (LASP).

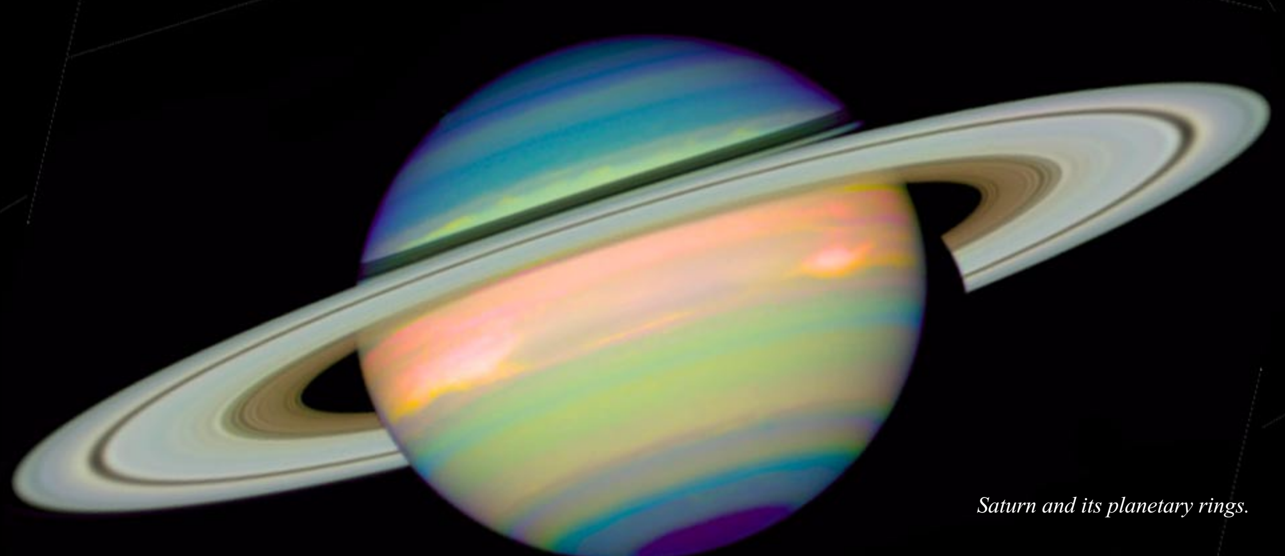
Science Background

Collisions between small particles in planetary rings frequently occur at very low speeds. In fact, many collisions can be less than 1 centimeter per second (at this speed it takes more than a full minute to travel only 2 feet). In a planetary ring, such as around Saturn, there is very little gravitational pull between the rocks and dust that make up the ring. As a result, even these very slow collisions can result in material being ejected from the collision, or the particle itself can rebound. Understanding the release of dust from the surfaces of these small rocks is crucial to understanding the evolution of not only planetary rings, but even the early stages of planet formation.

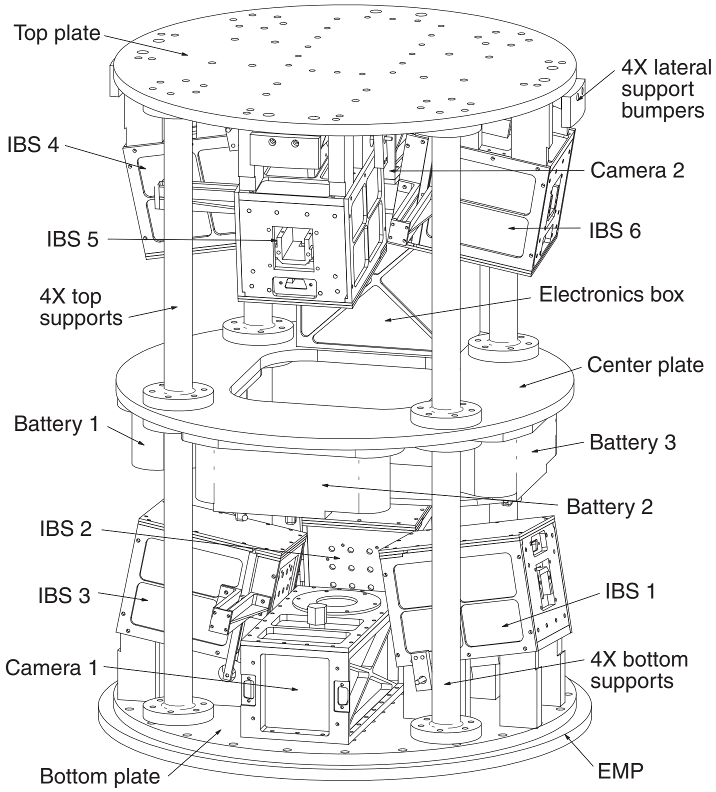
COLLIDE–2 will spring-launch small quartz projectiles into trays of powder designed to simulate space or lunar dust. The principal investigator (PI) will then study these impacts to determine how these speeds and other conditions relate to the production of dust. The COLLisions Into Dust Experiment-1 (COLLIDE–1) provided the unanticipated result that below a certain threshold energy, no material is ejected as a result of the impact. COLLIDE–2 will try to identify precisely where the threshold energy lies.

Experimental Objectives

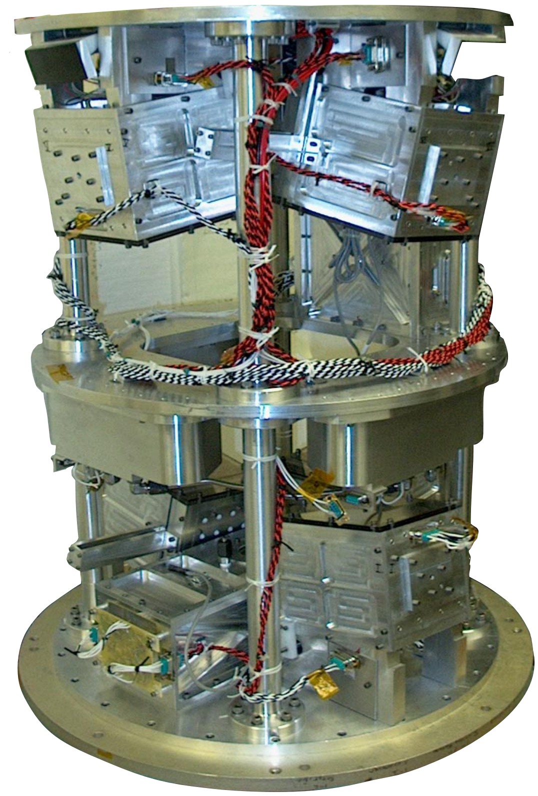
1. Measure the impact velocities and resulting rebound velocities to high precision (within 1 percent). From these measurements, determine the accretion efficiency for collisions in planetary rings and protoplanetary disks.
2. Identify the transition regime from low-velocity collisions where no mass is ejected to conditions where craters are formed and mass is ejected as a result of the impact.
3. Determine the mass and velocity distribution of the ejected material as a function of impact parameters.
4. Determine the dependence of coefficient of restitution (a measurement of how well the projectile "sticks" to the target material) on impact velocities for velocities ranging between 1 and 100 cm/s.



Saturn and its planetary rings.



The COLLIDE–2 hardware includes six IBS's, two video cameras, three battery boxes, and an electronics box with support structure.



The COLLIDE–2 experiment prior to integration into the Hitchhiker canister.

The Experiment

COLLIDE–2 performs six independent impact experiments and videotapes the results using two small camcorders. Each impact experiment takes place in an isolated box called an impactor box system (IBS) shown in the figure above. The IBS, which uses a spring-powered launcher, is specially designed to send its marble-sized projectile at a snail's pace into a target composed of loosely-packed powder. The launchers were tested on NASA's KC–135 airplane which provides 15 to 20 seconds of weightlessness. Because the projectile speeds are so low (1 to 100 cm/s), quartz projectiles barely moved when tested on the ground. The impactor box has a clear top to allow the camcorder to see the impact, and a mirror inside the box provides a second view. In order to simulate the conditions in space, the experiment must be run in a vacuum as well as in the microgravity environment afforded by the space shuttle. The camcorders need air to operate, though, so each of the two camcorders is contained in a sealed box filled with air. The videotapes will show how much powder is released in the impact and at what speeds simulating collisions that occurred in the earliest history of our solar system and in the distant rings of Saturn.

The COLLIDE–2 experiment apparatus is contained in a standard "Hitchhiker" canister which provides a standard mechanical and electrical interface to the space shuttle. The entire experiment is powered by eight standard D cell batteries with two backup sets of batteries. On launch, a pressure-sensitive switch outside the canister closes COLLIDE's power circuits, and its internal electronics begin a 14-hour countdown. Fourteen hours later, while the astronauts are sleeping, COLLIDE's six impact experiments run in sequence. The entire experiment finishes about one-half hour later. The videotapes contain all the scientific data and are analyzed frame-by-frame after the space shuttle returns COLLIDE–2 to Earth.

Payoff

- Extends fundamental knowledge of astrophysical disks
- Provides broader context for interpreting ground-based data
- Video of unique impacts in microgravity is useful for educational purposes
- Studies of the behavior of dust in microgravity has broad applications for space flight and experimentation

For more information, visit the
COLLIDE web site at
http://lasp.colorado.edu/collide/

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