

# Lunar GRAIL

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An artist's concept of GRAIL in action. Credit: NASA

Meet MIT professor of physics Maria Zuber. She's dynamic, intelligent, intense, and she's on a quest for the Grail. No, not *that* Grail.

Zuber is the principal investigator of the Gravity Recovery and Interior Laboratory — "GRAIL" for short. It's a new NASA mission slated for launch in 2011 that will probe the moon's quirky gravity field. Data from GRAIL will help scientists understand forces at play beneath the lunar surface and learn how the moon, Earth and other terrestrial planets evolved.

"We're going to study the moon's interior from crust to core," says Zuber. "It's very exciting."

Here's how it works: GRAIL will fly twin spacecraft, one behind the other, around the moon for several months. All the while, a microwave

ranging system will precisely measure the distance between the two satellites. By watching that distance expand and contract as the two satellites fly over the lunar surface, researchers can map the moon's underlying gravity field<sup>1</sup>.

Scientists have long known that the moon's gravity field is strangely uneven and tugs on satellites in complex ways. Without course corrections, orbiters end their missions nose down in the moondust! In fact, all five of NASA's Lunar Orbiters (1966-1972), four Soviet Luna probes (1959-1965), two Apollo sub-satellites (1970-1971) and Japan's Hiten spacecraft (1993) suffered this fate.

The source of the gravitational quirkiness is a number of huge mascons (short for "mass concentrations") buried under the surfaces of lunar maria or "seas." Formed by colossal asteroid impacts billions of years ago, mascons make the moon the most gravitationally lumpy major body in the solar system. The anomaly is so great—half a percent—that it actually would be measurable to astronauts on the lunar surface. A plumb bob held at the edge of a mascon would hang about a third of a degree off vertical, pointing toward the central mass. Moreover, an astronaut in full spacesuit and life-support gear whose lunar weight was exactly 50 pounds at the edge of the mascon would weigh 50 pounds and 4 ounces when standing in the mascon's center.

To minimize the effects of mascons, satellite orbits have to be carefully chosen. GRAIL's gravity maps will help mission planners make those critical decisions. Moreover, the maps GRAIL scientists will construct are essential to NASA's intended human landing on the moon in the next decade. The gravity of the moon's far side and polar regions, where future landings are targeted, is least understood.

The GRAIL team aims to map the moon's gravity field so completely that "after GRAIL, we'll be able to navigate anything you want anywhere

on the moon you want," says Zuber. "This mission will give us the most accurate global gravity field to date for any planet, including Earth."

GRAIL will also help students learn about gravity, the moon, and space. Each satellite will carry up to five cameras dedicated to public outreach and education. Undergraduate students supervised by trained adults will remotely operate the cameras from a facility at the University of California, San Diego, that currently operates similar cameras on the International Space Station.

Middle school students from all over the country will also get to join in the excitement of lunar exploration. "We'll have an interactive website where the middle school students can make recommendations for targets to photograph and then view the pictures of their suggested targets," she says. "This just has incredible potential to engage students."

Source: Science@NASA, by Dauna Coulter

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