

The Attraction of Gravity (Jean Dominique Cassini Medal Lecture)

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The motion of planetary bodies, their interior structure, their shape, and ultimately their landscape, are all determined, more or less directly, by gravity. It is therefore not surprising that by measuring the orbital motion and the gravity field of planets and satellites we have been able to gather crucial information on the interior structure and evolution of those bodies, and at the same time to put the laws of gravity to the test. Planetary geodesy is now a fully developed discipline that uses methods and observable quantities adopted also in other fields, such as space navigation and telecommunications. Thanks to this winning synergy between science and engineering, we can now measure spacecraft velocities to 10^{-6} m/s and accelerations to 10^{-9} m/s² over time scales as short as 1000 s, everywhere in the solar system.

The past ten years have seen outstanding results in the scientific exploration of the deep space, with gravity investigations contributing to the success of many missions. Thanks to gravity measurements, MESSENGER was able to unveil the main features of Mercury's interior structure. GRAIL, the first planetary mission entirely devoted to gravity, recovered the structure of the lunar gravity anomalies to a spatial resolution and accuracy unmatched even for the Earth. The discovery and characterization of habitable environments in the Saturnian system, on Enceladus and Titan, were possible also by the radio science investigations of the mission Cassini. Thanks to a carefully designed orbit, with a pericenter just 3000 km above the cloud level, the spacecraft Juno is now carrying out precise gravity measurements at Jupiter to unveil the interior structure of the planet and the depth of its winds. With Cassini providing similar information at Saturn in the Grand Finale orbits, just before the final plunge into the planet, we will soon be able to reveal how similar or different the two gas giants are.

But the interior structure of many planetary bodies remains elusive, and much remains to be explored. New missions and new tools are needed. In the next five years the planetary community will see the launch of BepiColombo and JUICE, two spacecraft equipped with a powerful suite of instruments devoted to the tomography of Mercury and Ganymede. Innovative instrumentation and probes are being conceived and designed. The Cassini Medal Lecture will review the past successes and future trends of planetary geodesy and radio science, from the peculiar perspective of someone whose attraction for gravity kept him at the ill-defined boundary between science and engineering, measuring angles, distances and velocities in the solar system.