The Cassini Gravitational Wave Experiment

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Doppler tracking experiments using the earth and a distant spacecraft as separated test masses have been used for gravitational wave (GW) searches in the low-frequency (~0.0001–0.01 Hz) band. The precision microwave link continuously measures the relative dimensionless velocity, delta_v/c, between the earth and the spacecraft. A GW incident on the system produces a characteristic signature in the data, different from the signatures of the noises.

For 40 days centered about its solar opposition in December 2001, Cassini was tracked in a search for low-frequency GWs. Because of instrumentation upgrades on the spacecraft and on the ground, this joint NASA/ASI collaboration was the most sensitive Doppler tracking experiment to date. This improved sensitivity was mainly due to two technical upgrades: (1) use of a higher radio frequency tracking link (Ka-band, approximately 32 GHz, which suppresses noise from radiowave phase scintillation due to plasma irregularities along the line of sight) and (2) use of an advanced tropospheric calibration system (which allows calibration/removal of most of the tropospheric phase scintillation.) The new instrumentation could also allow broadening of the experiment's band to lower frequencies, where the sources are stronger and may appear at a larger SNR. These upgrades support not only the GW experiment, but also a Cassini relativity experiment at solar conjunction and the Cassini radio science experiments at Saturn.

Here we present the overall noise statistics of the observations, a comparison of the observed noises with the pre-experiment noise budget, and a discussion of the prospects for further GW sensitivity improvements using the Doppler tracking method.