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THE DATA ANALYSIS CHALLENGE OF THE MICROSCOPE SPACE MISSION

Abstract

The goal of the MICROSCOPE space mission, scheduled for launch in 2016, is to test the Weak Equivalence Principle (WEP) with a precision of 10^{-15}. The signal of interest is the difference of the accelerations of two test-masses made with different materials. These accelerations are measured by an ultra-sensitive electrostatic accelerometer onboard a micro-satellite equipped with a drag-free system. The challenge of the data processing is to find a violation signal around a well-defined frequency in data samples disrupted by deterministic perturbations and colored noise. To achieve this objective, we perform a regression analysis to estimate the WEP violation as well as instrument parameters. A long integration period corresponding to several orbits is needed to reach a sufficient signal-to-noise ratio. However, in flight, the measurement may suffer from numerous interruptions due to various causes: saturation events due to crackles of the thrusters tank or the multilayer insulation coating, micrometeorite impacts, and telemetry losses. We investigate the effect of these gaps on the performance of the WEP test and show that they cause a significant frequency leakage of the noise power. We present a regression method which cancels this effect and enables us to estimate the parameters of interest with a precision comparable to the complete data case, even if the noise power spectral density is not known *a priori*. The method is based on an autoregressive fit of the noise, which allows us to build a general least square estimator approaching the minimal variance bound. We apply this method to simulated measurements of the instrument in orbit, and show that it increases the precision by a factor 60 with respect to ordinary least square estimators. This analysis validates the integration times, the mission scenario and the processing tools to be implemented in the Scientific Mission Center. In addition, the outputs of the algorithm are used to faithfully reconstruct the signal in the missing intervals. While the proposed approach is applied to MICROSCOPE simulated data, it provides a robust method to estimate one or several deterministic components in the general context of time series with missing data affected by unknown colored noise.