ID de Contribution: **69** Type: **MÉTHODES D'ANALYSE DES DONNÉES**

A Statistical Inference Approach to Space-Based Interferometry

jeudi 15 octobre 2020 10:45 (15 minutes)

One of the main challenges of space-based interferometry for gravitational-wave detection is the cancellation of laser frequency noise, whose power culminates eight orders of magnitude above the gravitational-wave signal. The standard technique to remove this noise is time-delay interferometry (TDI), a set of linear combinations of delayed phasemeter measurements tailored to cancel noise terms. We examine TDI from a statistical inference standpoint, constructing a model likelihood that directly depends on single-link measurements and accounts for their correlations. Based on previous works demonstrating the relationship between TDI and principal component analysis, we build a compact framework for space-based gravitational-wave data analysis that minimizes the measurement variance. As an application, we show that it provides a compelling description of the LISA data analysis problem by demonstrating our ability to fit for inter-spacecraft light travel times, source parameters, and noise covariance components simultaneously.

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Classification de Session: Groupe de travail: Méthodes d'analyse des données