# Paris Observatory (OPAR) Analysis Center

Sébastien Lambert, César Gattano, Yann Ziegler, Ibnu Nurul-Huda, Christian Bizouard, Jean-Yves Richard, Christophe Barache, Teddy Carlucci

**Abstract** We report on operational and research activities directly related to VLBI at the Paris Observatory VLBI Analysis Center (OPAR) for calendar years 2015 and 2016. Our main achievements are (i) the emergence of a project on the Earth's interior by VLBI, (ii) the first direct estimate by VLBI of a deflexion parameter in the standard model extension (SME) framework, and (iii) the contribution to the validation process of the Gaia Data Release 1 catalog that used the competences of OPAR personnel in terms of assessments of reference frames.

## 1 Analysis Service

Paris Observatory Analysis Center OPAR continued operational analyses of VLBI diurnal and Intensive sessions. All the products, except SINEX files, were published on the OPAR Web site at

`http://ivsopar.obspm.fr`

together with exhaustive explanations and plots. SINEX files were only sent to the Data Centers.

SYRTE, Observatoire de Paris, PSL Research University, CNRS, Sorbonne Universités, UPMC Univ. Paris 06, LNE

OPAR Analysis Center

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## 2 Research Activities

### 2.1 Nutation and Earth's Interior

In the last two years, we began working on the analysis of nutation time series with the aim of getting accurate estimates of Earth's interior parameters relevant to the core and the inner core. Years have elapsed since Mathews et al. (2002) obtained their excellent results. The accumulation of new data by various geodetic and geophysical techniques is particularly encouraging for undertaking a re-exploration of the Earth's interior by means of surface measurements. Especially, improving the accuracy of the resonant period of the free inner core nutation (FICN) is critical to constrain the dynamical ellipticity and density of the inner core, deformabilities of the core boundaries under fluid pressure, constants characterizing the viscomagnetic coupling at the core boundaries, viscosity of the inner core, friction at the inner-core boundary, and topographic torques at the interfaces.

In Rosat et al. (2017), we used nutation time series and surface gravity measurements by superconducting gravimeters together with a Bayesian inversion method to obtain the resonant period of the free core nutation (FCN) and the FICN. Though the FCN resonant period was found to be consistent between the two techniques and within the Mathews et al. error bars, the large confidence interval found for the FICN led to the conclusion that the FICN was possibly not detected at all or was vitiated by the presence of a poorly modeled atmospheric annual nutation. In another study, Gattano et al. (2017) analyzed the full set of VLBI nutation series available from the IVS Data Centers and revealed inconsistencies between series that were sufficiently large to destroy the robustness of the FICN estimate.

These two studies encouraged us to undertake a more ambitious project in at least two directions. A natural continuation of Rosat et al. (2017) is the combination of nutation and surface gravity data in a single matrix and a global inversion of common geophysical parameters (i.e., Chandler, FCN, and FICN resonances). This project started in October 2016 with the arrival of Yann Ziegler, geophysicist, at SYRTE, on a one-year postdoc position supported by the CNES. The second direction consists of estimating the above-cited geophysical parameters from a single inversion of the VLBI delays in a standard global VLBI solution. It will be realized by Ibnu Nurul-Huda, who began a PhD thesis at SYRTE in October 2016.

### 2.2 Testing Lorentz Symmetry by VLBI

Violations of Lorentz symmetry can be described as part of the field theory in the frame of the standard model extension (SME), containing both general relativity and the standard model used in particle physics. A hypothetical violation of Lorentz symmetry would alter the VLBI delay. This change can be parameterized and estimated directly by the analysis of VLBI delays. We introduced the partial derivative of the parameter constraining the amplitude of the violation in the pure gravity sector and got a direct estimation to the level of $10^{-5}$ (Le Poncin-Lafitte et al., 2016). This work has two main qualities: firstly, it improves by an order of magnitude the constraint on the above-cited parameter with respect to previous studies using Gravity Probe B and binary pulsar data, and, on the other hand, it is based on a direct estimate as opposed to postfit estimates that are performed on the residuals.

### 2.3 Multitechnique Combination

OPAR facilities were used for creating inputs with Calc/Solve to the French DYNAMO software package that allows the combination of normal equations from VLBI, GNSS, SLR, LLR, and DORIS and with which we obtained a 13-year long EOP series based on the combination of VLBI and GNSS (Richard et al., 2016). In the near future, DYNAMO will directly read IVS combination SINEX outputs as well as SINEX outputs from other technique centers of the IERS. The goal of this enterprise is to provide an operational solution obtained from a consistent combination of VLBI, GNSS, Laser ranging, and DORIS in parallel to the IERS EOP 14 C 04 data.

### 2.4 Validation of Gaia DR1 Catalog

Personnel of OPAR were involved in the validation phase of the first Gaia Data Release (Gaia DR1) in the framework of the Gaia Data Processing and Analysis Consortium (DPAC) coordination unit 9 (CU9) (Arenou et al., 2017). Our segment of the full validation process consisted essentially of characterizing the deformation between the Gaia DR1 catalog and the ICRF2, for which we provided and tested a six-parameter transformation consisting of three rotations and a glide.

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