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Free Core Resonance parameters from diurnal strain tides recorded by the Gran Sasso (Italy) and Canfranc (Spain) underground geodetic interferometers

Antonella Amoruso and Luca Crescentini
Universita' di Salerno, Dipartimento di Fisica, Fisciano, Italy (antonella.amoruso@sa.infn.it)

The Free Core Nutation (FCN) is a retrograde mode related to the slight misalignment of the rotation axis of the fluid outer core and the elastic mantle, with a period of about 430 sidereal days in the celestial frame. In the Earth-fixed reference frame, the (complex) frequency of the Free Core Nutation (FCN) is inside the diurnal tidal band and causes a resonant response (Free Core Resonance, FCR) of some diurnal tidal waves to the tide-generating forces.
The FCN is usually investigated through its effects on gravity tides and Earth nutations. Here we analyse about 7 years of discontinuous strain records from two 90-m long laser interferometers (strainmeters) operating under the Gran Sasso (Italy) massif and about 4.6 years of discontinuous strain records from two 70-m-long laser interferometers operating the Central Pyrenees (Spain).
Starting from the expressions for the vector displacements due to diurnal and semi-diurnal solid tides, we express extension along any azimuthal direction in terms of three complex parameters (related to areal strain and the two shear strain components), which are functions of the latitude-dependent Love and Shida numbers. Those three complex parameters are affected by the FCR through three complex resonance strengths.
We find that we can infer 4 model parameters from the inversion of our data, i. e. from the comparison between amplitudes and phases of the measured and theoretical diurnal tides close to the resonance: the FCN period, the FCR quality factor, the imaginary part of one of the three resonance strengths, and the real part of another resonance strength. However, local deformation is distorted with respect to regional deformation because of siting effects. Coupling between local extension (measured by the interferometers) and regional deformation can be described by three coupling coefficients per interferometer, thus introducing 12 additional unknown in the inversions. We minimize misfit between amplitudes and phases of the measured and theoretical tidal strain jointly for all the interferometers by sampling the 4D model parameter space, while optimal coupling coefficients for each interferometer are computed through a simple matrix inversion at each sampled point.
Theoretical strain tides is corrected for the effects of the water load oscillations caused by ocean tides. We use FES2014 and TPXO9 ocean models, while the appropriate Earth model for different ocean load areas is chosen basing on the widths of the continental shelves nearby the stations and the inversion misfits.
Although we analyse records from two stations only and the amount of data is relatively small, our

results for the FCN period and (to some extent) the FCR quality factor are robust and comparable to those obtained from gravity tides and nutations. Moreover, we obtain reliable values of the resonance strengths and robust estimates of the coupling coefficients for all the interferometers.

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