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10th LISA Symposium, Gainesville Florida

May 20, 2014

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1 LOT : Lisa On Table

- The "optical" LOT
- The "electronical" LOT
- Current status of the experiment

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Results

- TDI : Time Delay Interferometry
- Some plots

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3 Conclusion

LOT : Lisa On Table, an electro-optical simulator of eLISA



- green : Command/Control
- red : measurement
- blue : LOT components

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2 blocks, each one simulating one satellite of eLISA

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- a heterodyne Mach-Zehnder interferometer
- each arm = "cat's eye" configuration : association of lens, polarizing plate, mirror and acousto-optical modulator

-> allows to generate the optical beat signal + noise without loosing alignement between the distant and local arms due to frequency shift

LOT : Lisa On Table, an electro-optical simulator of eLISA, electronics part



Improvement of the experiment

- thermal insulation of the optical bench
- use of air cushion
- heat device to reduce turbulences by creating temperature layers
- further improvements for the future :
 - piezo oscillators on the mirror for active correction of the optical path lenght
 - transfer into a vacuum chamber
 - replacement of the NI device by a FPGA card
 - implementation of electro-optical modulators to simulate clock noise corrections
 - coupling with LisaCode to simulate realistic variable delays and frequency shifts due to orbitography and doppler effect

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Active compensation of optical path



- order 11 at *f_{laser}* + 2x110MHz + noise
- order 00 at *f_{laser}* used for homodyne interferometry
 -> dark fringe to lock the feedback system
- local mirror oscillates at 30kHz to modulate laser signal
- distant mirror receives correction signal from the feedback system which uses the 30kHz reference and the photodiode output

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TDI : Time Delay Interferometry



First generation TDI :

$$X_{1^{st}} = (1 - D_{31'}D_{1'3})s_{TT;1} - (1 - D_{2'1}D_{1'2})s_{TT;1'}$$

 a post-measurement treatment to reduce significantly the laser frequency noise level

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First results

10² LASD(freg chan 1) LASD(freg chan 2) LASD(freq chan 3) 10⁰ LASD(freg chan 4) LASD(TDI f34) ASD (Hz/sqrt(Hz)) 10-2 10 10 10-2 10⁻¹ 10⁰ 10¹ Frequency [Hz]

Illustration of TDI performance on triangular frequency fluctuations : the main pic is nearly entirely suppressed

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TDI without local noise and equal length (noise reference level)



Attenuation of 5.10⁷ for optical LOT and 2.10¹⁰ for electronical LOT at

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1mHz

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TDI with 3 arms noise and equal length



Same performance as for the configuration with no noise on local arm

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TDI with 3 arms noise and unequal length



Also a 5.10^7 attenuation for optical LOT but "only" 1.10^9 for electronical LOT

-> interpolation order + jitter

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Conclusion

- a complete hardware simulator of eLISA
- application of first TDI generation on a hardware simulator successfull
- further improvements to reduce intrinsic noise are underway :
 - active compensation of optical path to get nearly the same performance on optical and electronic LOT
 - implementation of FPGA to bypass NI system to have perfectly synchronized output commands with reduced time jitter
- Forthcoming developments :
 - Time variable delays and frequency shifts (TDI 2nd generation)
 - eLISA clock synchronization scheme with EOMs
 - arm-locking (thanks to FPGA)
 - improved electronics synchronized clocks with frequency reference from a stabilized optical frequency combination

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