Links between instrument developments and science with Gravitational Waves:

the LISACode simulator & studies of robust data analysis and calibration methods

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Situation

➢ Mission accepted: we need now to make it as best as possible.

➢ Large developments and studies done for LISA and eLISA on:
  • Instrument developments and research on high level technologies.
  • Data analysis and science with gravitational waves.

➢ BUT there is very little connections between these two aspects ...

➢ → developments of instrument, data analysis and studies of science efficiency of eLISA have to be consider COHERENTLY.

➢ One example of potential problem:
  • periodicity and not stationarity of the noise that can mimic sources or at least, makes the matched filtering more complex for long standing GW sources.
  • High noise observed: instrument or stochastic background ?
First ideas for “connections”:

- Several kind of simulators:
  - How they compare?
  - Are they complementary?
  - Hardware versus numeric

- Include realistic noises in MeLDC (already plan)

- Connections between IOT (Instrument Operation Team) team and DPC (Data Processing Centre)?

- Set up calibration procedures ...

- How GW sources could be use to calibrate the instruments?

- ...

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Calibration ...

➢ Use verification binaries to calibrate the noise level ...

➢ Define calibration procedures:
  • Example: Stochastic background from phase transition, cosmic strings: can we really differentiate it from instrumental noise, in particular if it is high and “cover” other GW sources?
  → Can we do something on instrument to identify the source of this “noise”.

→ Some studies started ...
Data analysis

➢ DA of “known” sources with well known waveforms:
  • Mainly matched filtering.

➢ DA of “known” sources with leak of understanding on waveforms:
  • DA using generic waveforms,
  • Robust methods (wavelets, ...).

➢ DA of unknown sources
  • Robust methods

➢ DA noises (part of the task of Instr. Op. Team):
  • Robust methods ?

→ Robust methods and methods based on “generic” waveforms need to be studied.
LISACode

- Scientific simulator for LISA type mission (C++)
- GW modeling, noises modeling, transfer functions, orbits, clocks, TDI, sensitivity generator, simple MCMC, ...
- Used in MLDC,
- Used for NGO/eLISA design,
- Flexible,
- ...

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Studies started at APC

- eLISA noises simulator
- LOT
- LISAPathfinder complementary data centre
- Data analysis and MeLDC
- eLISA Data Processing Centre
- LISACode
Studies started at APC

- Data analysis and MeLDC
- eLISA Data Processing Centre
- eLISA noises simulator
- LOT
- LISAPathfinder complementary data centre

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LISA On Table

- Electro-optical simulator for eLISA:
  - optic: interferometry.
  - electronic: delay, noise generation.
  - noise injection through AOM.
  - Hardware test of TDI.

→ Connection with LISACode:
  - LISACode as noises generator for the LOT.
  - LOT provides noise time series to LISACode.

Pierre Gruning's talk
Studies started at APC

- eLISA noises simulator
- LOT
- Data analysis and MeLDC
- eLISA Data Processing Centre
- LISAPathfinder complementary data centre
eLISA Noises Simulator

- State Space Model Simulator:
  - eLISA orbits,
  - Attitude controllers,
  - Test mass control,
  - Actuation and sensing noises,
  - ...

→ Detailed simulations providing inputs to LISACode in the form of time series and transfer functions.

Henri Inchauspé's talk
Studies started at APC

- eLISA noises simulator
- LOT
- Data analysis and MeLDC
- eLISA Data Processing Centre
- LISAPathfinder complementary data centre
Data Processing Centres

- LISAPathfinder Complementary Data Centre: François Arago Data Centre:
  - Offline analysis for the LPF mission
  - Extensive computation using the FACe cluster, ...
    → direct injections LISAPathfinder measurements (extrapolated for eLISA)

- eLISA Data Processing Centre in France:
  - CNES Phase 0 conducted in 2013: feasibility, cost, studies of different computing strategies, ...
  - Core of DPC will start to be build soon & can support some of the eLISA activities.
    → run simulation for noises and GW astrophysics
    → test data analysis
Studies started at APC

- eLISA noises simulator
- LOT
- eLISA Data Processing Centre
- LISAPathfinder complementary data centre
- Data analysis and MeLDC

Mock eLISA Data Challenge & Data Analysis

- A large number of development already done within the context of the MLDC (2005-2012):
  - Most part of the methods based on matched filtering
  - Limitations: limited number of sources, very simple noise

- Future: Mock eLISA Data Challenge (MeLDC)

  → Developments needed:
  - Matched filtering methods considering realistic noises and large number of GW sources,
  - Methods based on generic waveform,
  - Development robust methods.
Conclusion

➢ We need coherent developments on instrument, on data analysis and on science with GW.
➢ Calibration methods have to be defined.
➢ Data analysis for instruments and GW signal.
➢ Studies start at APC with LISACode simulator as a central connector between:
  • LISA On Table,
  • eLISA noises simulator,
  • LISAPathfinder Complementary Data Centre,
  • eLISA Data Processing Centre,
  • Data Analysis developments and MeLDC.
Thank you!