7th Einstein Telescope Symposium: 'the first joint ET-LIGO 3G meeting'

Tuesday 02 February 2016 - Wednesday 03 February 2016

Florence

Book of abstracts

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Parametric amplification to improve the sensitivity of next generation detectors at high frequency.

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We would like to discuss the possibility of further improvement of the ET/CE sensitivity at high frequencies using parametric amplification techniques. There are several regimes so we can combine those ideas to make one discussion session.

Poster session / 1

Length sensing and control for Einstein Telescope Low Frequency

Ms. ADYA, Vaishali [1]

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In this poster we describe a feasible length sensing and control scheme for the low frequency interferometers of the Einstein Telescope (ET-LF) along with the techniques used to optimise several optical parameters, including the length of the recycling cavities and the modulation frequencies, using two numerical interferometer simulation packages:
Optickle and Finesse. The investigations have suggested the use of certain combinations of sidebands to obtain independent information about the different degrees of freedom. We have also looked at various combinations of phase and amplitude modulated sidebands to obtain a diagonal sensing matrix.

Poster session / 2

Seismic noise studies at the ET candidate sites

Prof. BULIK, Tomasz [1]; Dr. SUCHENEK, Mariusz [2]; ROSINSKA, dorota [3]

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We present the current status of the seismic studies using the seismometers developed by the Warsaw group. We show the measurements of the sensitivity of the instruments. The instruments have been installed at the Ksiaz Castle site in Poland, and currently we are installing at two additional sites: the Matra mine in Hungary, and in Sos Ennatos mine in Sardinia. We will present the preliminary results, and discuss further installations and measurements.

Global Scenario / 3

Welcome

Global Scenario / 4

Motivations. (Why we are here)

Corresponding Author: michele.punturo@pg.infn.it

The targets of the present workshop are presented

Global Scenario / 5

3G science

Corresponding Author: b.sathyaprakash@astro.cf.ac.uk

Questions:
a) What are the ultimate science goals for ground GW detectors? (e.g., see all BH inspirals in universe with significant signal >1 Hz)
b) What will we already have done / can we do with aLIGO/AdV by 2030 (or so): guess e.g., 3x better than design sensitivity to 10 Hz
c) is what remains enough scope to motivate new Observatories? does it point to specific design needs (e.g., LF, triangles, number of observatories)?
d) given the long term perspective of a 3rd generation GW observatory, what is it that remains? How to assess the scientific importance and needs of the currently unknown?
e) what is the possible configuration of the future mixed network of 2G+ detectors and 3G observatories; specifically, is there a role for ~3-4 km surface instruments?
f) what are the next actions in this domain?

Global Scenario / 6

Q: Urgent questions 1

Corresponding Author: alicia.sintes@uib.es

Global Scenario / 7

Multi-messenger in 3G scenario

Corresponding Author: massimiliano.razzano@pi.infn.it

a) What are the multi-messenger physics in a 3G scenario; also with LISA?
b) What are the e.m. detectors we expect in the next two decades?
c) What actions from GW community should be taken to facilitate this?
d) what GW network capabilities are needed?
e) what are the next actions in this domain?

Global Scenario / 8

Discussion

Corresponding Author: alicia.sintes@uib.es

Global Scenario / 9

Requirements of a 3G observatory

Corresponding Author: harald.lueck@aei.mpg.de

1) What are the requirements of a 3G observatory?
Possible keywords:
a) wideband;
b) capacity to resolve the two polarisations;
c) longevity
d) capacity to host different topologies

2) what are the next actions in this domain?

Global Scenario / 10

Discussion

Corresponding Author: adf@star.sr.bham.ac.uk

Global Scenario / 11

Research Infrastructures: costs and characteristics of an underground infrastructure like E.T.

Corresponding Author: jo@nikhef.nl

- What are the scaling laws (performance and cost) for an underground observatory as a function of length?

- What are the next actions in this domain?

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Research Infrastructures: costs and characteristics of a surface infrastructure that satisfies the observatory requirements

Corresponding Author: mevans@ligo.mit.edu

- What are the scaling laws (performance and cost) for a surface observatory as a function of length
- What are the next actions in this domain?

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Discussion

Corresponding Author: adf@star.sr.bham.ac.uk

Global Scenario and Roadmapping / 14

GWIC roadmap update

Corresponding Author: sheila.rowan@glasgow.ac.uk

Highlights on the update of the GWIC roadmap

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Discussion

Corresponding Author: somiya@phys.titech.ac.jp

Global Scenario and Roadmapping / 16

Evolution Timeline in LIGO

Corresponding Author: dhs@ligo.mit.edu

a) What are the current instrument timelines for initial operation and incremental upgrades
b) What plausible timelines do we see for major observatories in the US and in Europe
c) What are the key questions that need to be pursued to firm up timeline?
d) what are the next actions in this domain?

Global Scenario and Roadmapping / 17

Evolution timeline in Virgo

Corresponding Author: giovanni.losurdo@ego-gw.it

a) What are the current instrument timelines for initial operation and incremental upgrades
b) What plausible timelines do we see for major observatories in the US and in Europe
c) What are the key questions that need to be pursued to firm up timeline?
d) what are the next actions in this domain?

Global Scenario and Roadmapping / 18

ET possible timeline

Corresponding Author: michele.punturo@pg.infn.it

The possible timeline of the Einstein Telescope project, considering the European and international scenario, is discussed

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Discussion

Corresponding Author: somiya@phys.titech.ac.jp

Global Scenario and Roadmapping / 20

Summary of the technology session and of the poster session: What R do we need?

Corresponding Author: fafone@lnf.infn.it

Based on the outcomes of the Technology session, in this talk the main R activities needed to develop future GW detectors are discussed

Global Scenario and Roadmapping / 21

Discussion

Corresponding Author: barsuglia@apc.univ-paris7.fr

Global Scenario and Roadmapping / 22

Funding large science projects

Corresponding Author: reitze@ligo.caltech.edu

a) what funding avenues exist for ~1BN scale projects?
b) what recent examples do we have to help us form successful proposals?
c) funding - how and when to decide on a global 3rd gen. scenery? We will need a good understanding of options and probability of funding levels. How to deal with the uncertainty?
d) what near-term activities should be put in motion from the standpoint of strategy?
e) what are the next actions in this domain?

Global Scenario and Roadmapping / 23

Governance of a 3G observatory

Corresponding Author: federico.ferrini@ego-gw.it

Which kind of governance shall we prefer (also depending on the funding scheme):
- particle physics like (CERN, ILC,…)?
- astronomy like?
what are the next actions in this domain?

Global Scenario and Roadmapping / 24

Discussion

Corresponding Author: lazz@ligo.caltech.edu

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Setting up the path-Teams-Next steps

Corresponding Author: michele.punturo@pg.infn.it

Technologies / 26

Newtonian Noise

Corresponding Author: jan.harms@fi.infn.it

1) what is the NN noise as a function of depth?
2) assess the various approaches to mitigation of NN and the R — nature, place — and timeline for R to choose among them
3) constraints on Observatory design (e.g., spherical ends for underground instruments)

Technologies / 27

Newtonian Noise subtraction R&D

Corresponding Author: jo@nikhef.nl

What kind of technology do we need to efficiently subtract NN?

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Discussion

Corresponding Author: mandic@physics.umn.edu

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Cryogenics for future GW detectors

Corresponding Author: rana.adhikari@ligo.org

a) impact of the cryogenic solution on the interferometer design and on the infrastructure;
b) what R we need?
c) what are the next actions in this domain?

Technologies / 30

An example of cryogenic, underground detector: KAGRA

Corresponding Author: miyoki@icrr.u-tokyo.ac.jp

What kind of difficulties have been encountered?,
What technology needs still to be developed

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Discussion

Corresponding Author: fulvio.ricci@roma1.infn.it

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3G Observatory design options

Corresponding Author: stefan.hild@glasgow.ac.uk

a) interferometry — topology, filter cavities, etc.
b) test mass configurations e.g.,Kahili cavities
c) redundancy, null stream, polarization
d) xylophones, possibilities for sharing Beam Tubes
e) what are the next actions in this domain?

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Discussion

Corresponding Author: lisabar@ligo.mit.edu

Poster session / 34

Losses estimation in a 300-m filter cavity and quantum noise reduction in the KAGRA gravitational-wave detector

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The sensitivity of the gravitational-wave detector KAGRA, at present under construction, will be limited by quantum noise in a large fraction of its spectrum. The most promising technique to increase the detector sensitivity is the injection of squeezed states of light, where the squeezing angle is rotated by a Fabry-P´erot filter cavity. One of the main issues in the filter cavity design and realization are the optical losses given by the mirror surface imperfections. We present a study of the specifications for the mirrors to be used in a 300-m filter cavity for the KAGRA detector. A prototype of the cavity will be constructed at National Astronomical Observatory of Japan (NAOJ), in the infrastructure of the former TAMA interferometer. We also discuss the potential improvement of the KAGRA sensitivity, based on a model of various realistic sources of losses and their influence on the squeezing amplitude. The results of this work can be easily extended to any gravitational-wave interferometric detector planning the use of filter cavities with length of several hundreds of meters.

Poster session / 35

Large band low frequency sensors based on Watt's linkage for future generations of interferometric detectors of gravitational waves

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A Folded Pendulum is a very effective mechanical system for the implementation of uniaxial (horizontal and/or vertical) and triaxial seismometers and accelerometers for ground, space and underwater applications, including ultra-high vacuum and cryogenic ones.
The Folded Pendulum innovative architecture developed by the University of Salerno, based on the classic Watt-linkage mechanical configuration, allows the design and implementation of very large band sensors (10−7 Hz − 100 Hz), characterized by very high quality factors (Q > 2500 in air, Q > 15000 in medium vacuum) and sensitivities that, for the most common applications, do not depend on the mechanics, but only on the readout techniques (< 10-12 m/sqrt(Hz) with typical Virgo LVDT readout). These unique features, coupled with other very relevant characteristics, like full scalability, high compactness (< 10 cm), lightness (< 300 g), high directivity (> 10000), tuneability (typical mechanical resonance frequencies are in the band 70 mHz − 10 Hz), very high immunity to environmental noises make this class of sensors suitable both as seismic and newtonian noise sensors and as control sensors for mechanical suspensions for future generation of interferometric detection of Gravitational Waves.
Two different versions of Folded Pendulums, configured both as seismometers (without force feedback) and as accelerometers (with force feed-back), integrated with a standard Virgo LVDT readout and the new electronics control boards developed by the Pisa group for Advanced Virgo, are presented here together with the main relevant characteristics and parameters as resulting from tests performed in the Applied Physics Laboratory of the University of Salerno and in the Electronics Laboratory at Virgo (Cascina) EGO.

Keywords: Seismometer, Accelerometer, Folded Pendulum, Monolithic Sensor, digital control, data acquisition.

Poster session / 36

Amorphous silicon for highly-reflective mirror coatings

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To match requirements of ET and possible cryogenic upgrades to aLIGO, thermal noise in highly-reflective mirror coatings has to be significanlty reduced. Due to a high refractive index and low mechanical loss at cryogenic temperatures, amorphous silicon (aSi) is a very promising material.
The absorption of highly-reflective aSi/SiO2 coatings at 1550nm has been shown to be about 1000ppm and therefore far too high for application in gravitational wave detectors. This work presents investigations of the effect of heat treatment, cooling and different deposition methods on the absorption of aSi coatings, promising absorption results at 2um compared to 1550nm, and investigates the optimisation of the coating design to make use of aSi in mirror coatings for future detectors possible.

Poster session / 37

Results of Russian groups as the ET-ASPERA research

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The Russian Consortium formed by groups of three Institution SAI MSU,PD MSU and INR RAS has carried out a research in the frame of ET-R program,sec.W1-W3.The following results have been achieved

Some universal algorithm of a "search for coincidence" gravitational signals with neutrino events in the 100 second window was developed with statistical estimation of the "right detection"probability (W1). The spectrum density and correlation properties of seismic perturbations in the Baksan Neutrino Observatory were measured during a quiet period of time. The "newtonian gravity-gradient noise was calculated according to the experimental data of seismic spectrum density along the main tunnel of the BNO RAS (W2).
Mirrors at the CaF2 substrate formed a solid body FP cavity were tested at low temperature. Evolution of the integral optical characteristics such as finesse and contrast was monitored in the presence of optical pump 10 – 400 mW at the temperature interval 300-5 K. Observable variations did not exceed 20% (W3)

A new technology for manufacturing of silicon micro resonators with the whispering gallery mode was developed. Numerical models of micro resonator coupling with other optical elements were elaborated using the software package Comsol Mutiphysics (W3).

A mechanism for suppression of parametrical instability in a new generation of gravitational detectors was proposed through the selection of optimal curvature of mirrors and using resonators with sparse spectrum components. The effect of optical rigidity was recommended for enhancing sensitivity behind the standard quantum limit (W4).

Poster session / 38

Optical, electronical and mechanical properties of silicon at low temperatures

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Silicon is a candidate material for future gravitational wave detectors being operated at cryogenic temperatures. Operating silicon in the near infrared might be a solution for low noise operation. However, several optical properties of silicon are not known in the near infrared and at cryogenic temperatures.

We present current results on the investigation of optical, electronical as well as mechanical properties in a wide temperature range. Amongst them are carrier densities, optical absorption, the mechanical loss and its correlation to defects as well as the stress induced birefringence. The results as well as their implication to modern gravitational wave detectors are presented.

Poster session / 39

Control noise in ET-LF

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Some of the many technical challenges that the Einstein Telescope interferometers will present fall into the domain of controls. In particular, the ET-LF interferometer will have to suppress vast seismic motion at 1 Hz, while leaving the quantum noise limited sensitivity at 10 Hz as undisturbed as possible. In this poster we will present the early results from our longitudinal control noise investigations.

Poster session / 40

ENSEMBLE OF GALACTIC ROTATING NEUTRON STARS AS A SOURCE OF GRAVITATIONAL BACKGROUND FOR EINSTEIN TELESCOPE DETECTOR

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A spinning neutron star is a source of continuous gravitational waves, if its mass distribution is non-axisymmetric. Such asymmetry can be caused by various instabilities and deformations (e.g. Andersson, 2003, Gondek-Rosi´ska et al. 2003). We have performed calculations of the gravitational waves background produced by the ensemble of rotating neutron stars in the Milky Way. In our calculations we use a model of population of neutron stars which takes into account the distribution of birth places, kicks, and evolution of pulsars. We analyze the spatial shape and the spectrum of such background. We find that the signal is detectable above 20 Hz with a one year Einstein Telescope observations if the mean asymmetry is as high as 1/1000000