14th LISA SYMPOSIUM: JULY 25th – 29th 2022

Abstracts of Plenary talks

All times are CEST.

Monday July 25th

1100 – 1200 **Overview of Current LISA Status**

Martin Hewitson (Leibniz Universität Hannover/Max Planck Institute for Gravitational Physics), Oliver Jennrich (ESA/ESTEC), Linda Mondin (ESA/ESTEC)

In 2017, the LISA Consortium proposed the LISA mission in response to a call to address The Gravitational Universe theme as part of ESA's Cosmic Vision programme. Following the selection of the mission in 2017, ESA, NASA and the LISA Consortium have been working hard to refine the science case and define the mission architecture and requirements in preparation for its implementation. This talk will review the LISA Science, describe the mission architecture, and present the current status of the mission formulation.

1215 – 1255 **Electromagnetic Signatures of LISA Massive Black Hole Binary Coalescences**

Monica Colpi (Universita degli Studi di Milano Bicocca)

Multi-messenger astronomy which combines low-frequency gravitational wave observations of massive black hole coalescences with contemporary observations in the electromagnetic domain enables unique tests in the fields of astrophysics and cosmology. The possibility of performing these tests depends on both LISA's capability to well localise these sources in their pathway to coalescence, and for the new generation of telescopes to slew as fast as possible and scan deeply the corresponding galactic fields. By using the detailed information contained in a mock universe, we explore the habitat of the merging systems, the properties of their host galaxy and the detectability of an emerging X-ray activity.

1255 – 1335 **Time Delay Interferometry for LISA**

Jean-Baptiste Bayle (University of Glasgow and NASA Jet Propulsion Laboratory)

Contrary to ground-based gravitational-wave detectors, LISA will be an interferometer with unequal and time-varying arm lengths. Subsequently, the limited frequency stability of the laser sources appears as the dominant noise in the LISA measurements, 8 orders of magnitude above the expected gravitational-wave signals. This issue can be addressed by time-delay interferometry (TDI), an on-ground processing technique first proposed by Tinto and Armstrong. They showed that, under some assumptions, one can combine time-shifted correlated measurements to form laser noise-free combinations. Source detection and parameter estimation can then be performed on these combinations.

This presentation will first describe the original algorithm, using a toy model example to lay out the working principles of TDI. The second part of this talk will review the more recent studies on TDI (the search for all possible combinations and the study of their properties, its geometrical interpretation, the link with linear algebra and principal component analysis techniques) and the attempts to build and test L0-to-L1 pipeline(s).

1500 – 1520 **Building New Tools for Gravitational-Wave Astronomy**

Kaze Wong (Braccini Thesis Prize winner; Flatiron Institute)

There has been tremendous progress in gravitational-wave (GW) astronomy since 2015, including the first detection of a GW signal from a black hole binary, the first multi-messenger observation of a binary neutron star merger, and over 70 compact binary coalescence events in the current GW catalog. Next-generation detectors such as the Einstein Telescope (ET), Cosmic Explorer (CE) and the Laser Interferometer Space Antenna (LISA) should detect a wider variety of GW events at a hastening pace. It is important to think ahead and develop tools to address the challenges presented by the upcoming events. In this talk, I will talk about some new tools I think are important to the gravitational-wave community in the coming decade.

1520 – 1600 **LISA Stellar Mass Binaries**

Silvia Toonen (Universiteit von Amsterdam)

Ultra-compact stellar mass binaries make up the most plentiful of sources for the future GW detector LISA. Using LISA, we expect to reveal a large population of detached double white dwarf binaries, as well as binaries with neutron star & black hole companions, interacting sources such as AM CVn, and even multiple sources containing three or more bodies. In this talk, I will review our current expectations for these sources in terms of detections and science objectives in the LISA era. Which sources will we be able to detect with LISA, and what progress can we expect from individual detections or population demographics, on a range of topics such as the formation and evolution of compact binaries, interaction physics, and Galactic structure?

1615 – 1655 **Observations of Massive Black Holes**

Jessie Runnoe (Vanderbilt University)

Massive black hole binaries (MBHBs) with masses of 0.1-10 million Solar masses in low-redshift galaxies will be among the loudest sources of gravitational radiation at milli-Hz frequencies observable with the Laser Interferometer Space Antenna (LISA). While the detection of such systems with LISA will be groundbreaking, we can learn a great deal more if we can also detect their electromagnetic (EM) counterparts. To help identify the counterpart, early warning from LISA on-the-fly parameter estimation will yield time-evolving constraints on sky localization, luminosity distance, chirp mass, and mass ratio. But developing strategies to pick out the EM counterpart from all the candidates in the multi-dimensional error volume of the gravitational wave source requires a detailed inventory of this volume and a systematic evaluation of the credentials of the galaxies within it. With this in mind, I will review EM methods used to search for supermassive black holes (with masses ~>0.1 billion Solar masses), with an emphasis on some of the challenges these methods may face when translated down to lower masses relevant for LISA. I will also discuss efforts to incorporate large-area optical and infrared astronomical surveys in this context in order to inform joint multi-messenger detections.

1655 – 1735 **The LISA Global Fit**

Tyson Littenberg (NASA Marshall Space Flight Center)

The unique challenge of LISA analysis stems from the large number of overlapping gravitational-wave sources simultaneously detectable in the data at all times during observations. To maximize detection efficiency and minimize biases in source inferences a global parameterized fit to the data must account for the different source types, uncertainty in the number of detectable sources, and characteristics of the instrument including noise levels, artifacts, and calibration uncertainty. This presentation will lay out the challenges of the global fit; highlight similarities and contrasts with other gravitational wave experiments; lay out a framework for designing a global fit algorithm; demonstrate a state-of-the-art prototype pipeline in development for performing the global analysis; and discuss some interesting consequences the global nature of LISA inferences will have on the resulting source catalogs.

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Tuesday July 26th

1500 – 1530 **The LISA Gravitational Reference System**

Daniele Vetrugno (Universita di Trento)

The LISA Gravitational Reference Sensor (GRS) constitutes one of the fundamental pillars in the definition of the LISA gravitational wave sensitivity. It plays a leading role in the quality of the free-fall of the test masses and its performances inform several design aspects at MOSA (Moving Optical Sub-Assembly) and Spacecraft level. Also, it plays a central role in the DFACS control scheme.

The possibility to reach sub-femto g residual acceleration for the LISA test-masses has been demonstrated by LISA Pathfinder (LPF), and LISA will take maximum advantage from the LPF legacy. However, the extraordinary results of LPF are not fully understood yet, both in terms of noise model and spurious signals appearing in the data. Moreover, LISA will require some changes in the GRS design to adapt it to a new satellite configuration and new noises and experimental challenges appear in it.

Taking care of all these aspects will be of paramount importance both in the design phase of LISA and during the operations, in order to eventually enable the full potential of the amazing science of LISA.

1530 – 1600 **LISA Optical Benches**

Ewan Fitzsimons (UK Astronomy Technology Centre)

The LISA Optical Bench sits at the heart of the LISA instrument and is where the laser beams are prepared and combined together to produce the interferometric signals which contain our key science measurement. We will present the latest design of the LISA Optical Bench, discuss some of the challenges involved in its development, and give an overview of the status of the key technologies required to make it work.

1615 – 1645 **LISA Telescope Manufacturing and Testing Plans**

Jeff Livas (NASA Goddard Space Flight Center, for the LISA Telescope Team)

We will describe the current status and plans for manufacturing and testing of the Engineering Development Unit (EDU) telescopes. The presentation will discuss some of the key challenges for the design as well as for manufacturing and testing. It will also outline what changes may be needed to adapt the engineering model for flight as well as the analysis we have done to make sure that the designs are buildable and will meet requirements when multiple units are built.

1645 – 1715 **Testing the LISA Instrument at System Level**

Hubert Halloin (Université Paris Cité, APC, Paris)

The success of the LISA mission relies on the combination of different high performance sub-systems such as the telescopes, the optical benches, the GRS , phasemeters, etc.

In order to validate the integrated instrument concept and check the metrological performance of the qualification and flight models, a set of optical tests have been proposed prior to the integration of the instruments on the satellites.

These tests shall occur at two different integration levels. First, the stability of the pathlength measurement and the tilt-to-length (TTL) coupling will be measured with the engineering (and possibly qualification) models of the optical bench, phasemeter and laser source. Second, once the MOSAs have been integrated, different optical tests will be performed to check the sub-systems alignements, reduce the TTL coefficient and estimate the pathlength stability within the integrated instrument.

This presentation will describe the objectives of these tests, the proposed sequence and the foreseen design and expected performance of the required optical ground support equipment.

1715 - 1730 **LINCS: LISA Internal Networking Committee for Science**

David Weir (University of Helsinki)

The LISA Science Group (LSG) makes up the majority of LISA Consortium members, all of whom are keen to make the mission a success. However, it is not always easy to match the available expertise in the LSG to the work packages and other tasks needing done. Furthermore, communications within the LSG are sometimes fragmented, with information scattered across multiple different services and platforms. LINCS is a small committee within the LSG that seeks to both help people contribute more effectively to the mission, and also streamline internal lines of communication. In this short talk I will discuss LINCS's recent activities - such as creating a Consortium FAQ - and how we are helping to improve internal communications.

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Wednesday July 27th

1100 – 1140 **The James Webb Space Telescope**
Gillian Wright (UK Astronomy Technology Centre)

The James Webb Space Telescope launched on December 25th 2021, after more than two decades of development and testing. The talk will give a broad overview of the mission and technical challenges in what is one of the most ambitious projects in the history of astronomy. The scientific potential of the mission, and especially the MIRI instrument, will be illustrated with some of the first observations made.

1140 – 1220 **Astronomy and the Climate Crisis: Are We Part of the Problem or Part of the Solution?**
Victoria Grinberg (ESA)

Why should astronomers and physicists think and talk about the climate crisis? Is our research contributing to global warming? Can we just ignore what is going on or are we and is our work affected? What can we do if we decide, as individuals and as a community, that this is a global crisis that we need to address?

The above questions move more and more to the forefront of the current discussion within our field, triggered not only by the impending climate crisis, which already today leads to an increasing number of extreme weather events, but also by our experience of being thrown into a different mode of work and communication during the pandemic. In this talk, I will try to address them from the perspective as an active astronomy researcher and attempt to offer not only a summary of some of the recent findings in this area for (astro)physics, but also thoughts on how to be part of the solution instead of being part of the problem.

1235 – 1315 **Stochastic Gravitational-Wave Signals in the LISA Band**
Nikos Karnesis (Aristotle University of Thessaloniki)

As soon as LISA switches to science operations, we will immediately start measuring a plethora of gravitational wave signals. Some sources will appear with huge signal-to-noise ratios and they will be identified in the data stream with relative ease. On the other hand, there will be populations of sources that will generate a stochastic type of signal across the LISA band.

In this talk I will summarize the different possible contributions to the overall stochastic signal that we expect to measure with LISA, and also discuss the possible implications to data analysis.

1315 - 1330 **LISA Early Career Scientists: Overview and Updates**
Martina Muratore (Universita di Trento)

The LECS group within the LISA Consortium was born three years ago with the purpose of creating a positive, dynamic, vibrant, and inclusive environment within LISA for early career researchers. The goal of the group is to facilitate the interchange and development of ideas among early career scientists in LISA and to guide and support young scientists during their academic careers, helping them to fulfill their goals.

To this end, we have been running different activities and suggested initiatives that have involved a large community inside LISA and created a bridge to other early career researchers outside LISA. In this talk, we will introduce LECS to newcomers in the LISA community and we will provide a summary of the activities we plan to run in the next year leading up to adoption including the mentorship program.

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Thursday July 28th

1100 – 1140 **Animating the Science: Human Challenges in Large Astronomy Projects and Collaborations**
Kate Daniel (University of Arizona)

Physicists and astronomers are trained to solve complex problems in order to expand and deepen our understanding of the Universe. Historically these fields have been viewed as relatively dehumanized, holding the scientific enterprise as separate from the humans who animate it. Demographic data and an ever-increasing number of articles make it clear that there are systemic, inequitable barriers to participation in this great endeavor. In order to address these issues we must also invest in a well-organized, multi-faceted, intentional approach. In this talk, I will give a brief introduction to concrete, actionable suggestions that are largely informed by my work as a member of the Panel on the State of the Profession and Societal Impacts for the National Academies 2020 Decadal Review of Astronomy and Astrophysics (Astro2020). Our charge included a review of our field's demographics, diversity and inclusion efforts, workplace climate, workforce development, education, public outreach, benefits to the nation, and relevant areas of public policy. I will discuss a framework laid out by this panel and methods that can be implemented by large projects and collaborations. LISA is well poised to not only transform science across physics, cosmology, and astronomy, but to raise the bar for the field as a whole to support a thriving and diverse community of scientists.

2040 – 2055 **LISA Consortium DEI Update**
Alberto Sesana (Universita degli Studi di Milano Bicocca), Joey Key (University of Washington Bothell), Jeremy Wachter (Skidmore College)

The LISA Consortium Diversity, Equity, and Inclusion (DEI) Committee leads the LISA Consortium DEI efforts, including DEI events and opportunities for Consortium members as well as collaboration with external DEI professionals and organizations.

2055 – 2135 **2022: A LISA Odyssey. Some Personal Reflections**
Tuck Stebbins (University of Colorado), Bernard Schutz (Cardiff University)

We look back on the development of the LISA concept from its early beginnings in the 1970 and 80s to the time of its selection by ESA in 2016/17. Many of the initial technology concepts have proved very durable, as have some of the scientific objectives that have motivated the project from the beginning. Our reminiscences will be as much about the pioneers and the turbulent ups and downs of the project as about the science and technology.

2150 – 2230 **Public Gravitational-Wave Data: The Last Mile**
Jonah Kanner (California Institute of Technology)

The last mile problem in transportation describes the challenge of connecting people's homes to dense networks of transportation, such as subway systems. When creating a public data release, we have a similar last mile problem. A community of experts relies on a dense network of colleagues and resources to understand and utilize data from LIGO, Virgo, and KAGRA. If we want our public data release to be usable by a large, diverse audience, we need to create solutions that connect non-experts to this network of resources. This talk will explore solutions like workshops, web apps, and message boards to solve the last mile problem to support public data releases.

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Friday July 29th

1500 – 1540 **The Event Horizon Telescope**

Feryal Ozel (University of Arizona)

The Event Horizon Telescope (EHT) has obtained the first ever horizon-scale images of two supermassive black holes, Sagittarius A* and M87, at millimetre wavelengths. Such images offer the opportunity of testing the black hole metric. I will present new constraints on potential deviations from the Kerr prediction based on the 2017 EHT observations. I will describe how we obtain the images and how we calibrate the relationship between the geometrically defined black hole shadow boundary and the observed size of the ring-like images using a large library that includes both Kerr and non-Kerr simulations. For the case of Sgr A*, we combine this with the exquisite prior constraints on the mass-to-distance ratio based on stellar dynamics and show that the observed image size is within ~10% of the Kerr predictions. We use these bounds to place constraints on metrics that are parametrically different from Kerr as well as on charges of several known spacetime solutions. We also constrain alternatives to the presence of an event horizon by using the observed image size and the broadband spectrum of Sgr A*. I will discuss the synergy between this measurement and the constraints on the external spacetimes of black holes obtained through gravitational waves and how the combined observations can test the external spacetimes of black holes across a vast range of masses and conditions.

1540 – 1620 **Waveforms for LISA and 3G Ground-Based Detectors**

Deirdre Shoemaker (University of Texas at Austin)

The discovery potential of LISA and 3G ground-based gravitational wave detectors is immense and exciting. Realizing the scientific scope of these observatories, in many cases, requires source waveforms. I will discuss the current and future prospects in waveform development for the observatories, including the challenges ahead.

1635 – 1735 **Beyond LISA: Voyage 2050 Panel Discussion**

Chair: John Conklin (University of Florida). Panellists: Christopher Berry (University of Glasgow), Vitor Cardoso (IST, Lisbon), Irina Dvorkin (IAP, Paris), Natalia Korsakova (APC, Paris), Alessandra Buonanno (AEI, Potsdam)

In 2018, the ESA Director of Science established a Senior Committee of scientists to develop a plan, Voyage 2050, to follow Cosmic Vision and establish the ESA's Space Science Program up to 2050. One of the tasks of the Senior Committee was to make a recommendation on the science themes for the next three Large missions following JUICE, ATHENA and LISA. In this session we will reflect upon one of the three themes recommended for Voyage 2050, notably "New Physical Probes of the Early Universe", which could be addressed via gravitational-wave detectors.

Our panel draws upon the expertise of leading authors of the four white papers related to gravitational-wave science submitted to Voyage 2050

- Christopher Berry: The Missing Link in Gravitational-wave Astronomy: Discoveries waiting in the decihertz range
- Vitor Cardoso: Probing the Nature of Black Holes: Deep in the mHz Gravitational-Wave
- Irina Dvorkin: High angular resolution gravitational wave astronomy
- Natalia Korsakova: Unveiling the Gravitational Universe at μ-Hz Frequencies

Also joining the panel is Alessandra Buonanno, who was a member of the Voyage 2050 Senior Committee.