SATELLITE MEETINGS


2. International Gravitational Waves Outreach Group Meeting, July 13, 2019, Valencia (Spain). Link>

3. Gravity: New perspective from strings and higher dimensions, July 16–24, 2019, Benasque (Spain). Link>


5. XXXVII Reunión Bienal de la Real Sociedad Española de Física, July 15–19, Zaragoza (Spain). Link>
THE GRAVITATIONAL WAVE SPECTRUM

**Sources**
- Quantum fluctuations in the very early Universe
- Binary supermassive black holes in galactic nuclei
- Phase transitions in the early universe
- Black holes, compact stars captured by supermassive holes in galactic nuclei
- Binary stars in the galaxy and beyond
- Merging binary neutron stars and stellar black holes in distant galaxies; fast pulsars with mountains

**Wave Period**
- **Age of the Universe**
  - Inflation Probe
  - Polarization map of cosmic microwave background
- **Years**
  - Precision timing of millisecond pulsars
- **Hours**
  - LISA
- **Seconds**
  - BIG BANG OBS
- **Msec**
  - GEO, LIGO, VIRGO, TAMA

**Detectors**
- **Inflation Probe**
- Polarization map of cosmic microwave background
- Precision timing of millisecond pulsars
- LISA
- BIG BANG OBS
- GEO, LIGO, VIRGO, TAMA
Working in partnership…
LSC: a global community

As of 2019-07-01:

- 125 institutions on 5 continents (ligo.org)
- 1854 members (roster.ligo.org)
- LIGO mainly funded by US-American NSF (with significant contributions from UK, Australia, Germany)
- instrumental R&D, computing, data analysis, astrophysical interpretation, and public outreach all benefit hugely from international contributions
- LSC outreach always needs to span audiences from the local to the global levels.

From David Keitel’s LSC talk on Monday
LSC education & public outreach

- from the original LSC charter (2005):
  "...carry out an outreach program to communicate LIGO’s activities and goals to the public, and to provide educational opportunities for young people”
- official EPO group established 2008
- current chair: Martin Hendry (Glasgow), former chairs: Marco Cavaglia, Szabolcs Marka, Joey Key

- EPO activities are part of LSC member group’s MoUs and overall LSC program
the pillars of...

LSC EPO

LLO
LHO
GEO

tours & education

centers

formal education

schools colleges & unis

f2f fairs

conferences etc.

media contacts

political outreach

online ligo.org

social media

NEW public GW alerts

volunteers (and some great professional staff at LLO, LHO, CIT)
Science summaries

- one of our key EPO products.
- web page summaries of published papers; also pdf “flyer” versions for handouts at booths/events.
- produced by members of paper writing teams and further edited by EPO.
- translations (~5 languages) for detection summaries.
- More than 90 summaries since 2011
- Now core part of PWT responsibilities
- Focus for e.g. press interest, enquiries
EPO Social Media:

We have improved social media coordination with laboratories, institutions, consortia and other GW projects.

Current focus is on social media support for O3 public alerts
online: Humans of LIGO

humansofligo.blogspot.com

- highlighting the humans behind our science
- with a focus on:
  - younger members
  - under-represented groups
  - people with unusual career paths or hobbies
- recognition for the founding human
online: videos

- two main dissemination channels:
  - ligo.org
  - youtube.com

Visit the LIGO-Virgo YouTube channel for documentaries, explainers, talks, and more! Also check out videos and audios below:

**MULTIMEDIA**

**VIDEOS, AUDIOS**

**LIGO PRIMER**

Watch the videos in this section to learn about what gravitational waves are, how they will be detected, and where they come from.

- great materials (e.g. NR visualisations) also on member group YouTube pages

- special mention to Kai Staats:
  → vimeo.com/kaistaats
online: support of LVC public alerts

- #O3ishere – LVC now delivering public low-latency GW alerts to all professional and amateur astronomers, to maximise multimessenger science opportunities
- for scientists: GCNs and gracedb.ligo.org database
- detailed info for astronomers: emfollow.docs.ligo.org/userguide
- for full scientific scope, see K.Chatziioannou’s plenary talk (Tue 12:00)
# Exhibits

**Astronomy's new Messengers**

*Listening to the Universe with Gravitational Waves*

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**2009: $1M NSF-funded travelling exhibits.**

- Featured at WSF, USA SEF, many other US venues
- Not well-suited to “pop up” events: even the small version takes ~3 hours to assemble!...
Exhibits

Recent focus on greater **flexibility** and **scalability** – creating easily portable exhibit resources to be used / shared across collaboration.
Overview of Virgo outreach activities

- About 80 european institutes
- About 400 members

Wide range of activities across Europe:
- Visits at the Virgo site
- Web site
- Activities on major social networks
- Participation to several events across Europe
- Participation to art&science exhibitions
- Dedicated initiatives to target some specific public
- Comics on GWs

www.virgo-gw.eu

No personnel hired specifically for outreach: only on voluntary basis
3d printed waveforms

Virgo

3d model of Adv Virgo, touchable

Sonified sky maps

Science exhibition: suspensions

Site visitors: 6k expected in 2019

Art & science exhibition multimessenger room

Comics on GWs

Racconti dal Bar Ronda

INFN
LISA Consortium reboots to build mission
Call for applications to the renewed LISA Consortium

Artist's impression of the new LISA constellation. © LISA Consortium

LISA Consortium Reboot
We are now ready to reboot the Consortium and ask you to apply. You will find all necessary information on the Application Portal here:
https://signup.lisamission.org
LISA Consortium Advocacy and Outreach Working Group

Context: a draft “mission statement”

The Advocacy and Outreach (a.k.a. “AdvoReach”) Working Group aims to promote, support and coordinate:

1. communication and regular exchange of information between the mission teams and working groups within the Consortium, and with the broader LISA community;
2. coordination, as appropriate, with outreach projects and activities carried out by other Gravitational-Wave communities (e.g. LIGO, Virgo, NANOGrav, etc);
3. outreach to the wider astronomical community - particularly in common science areas, advocating for LISA and emphasising the complementarity of LISA science;
4. promotion and raising awareness of LISA to different non-science audiences – specifically the general public, journalists, politicians and other decision makers – in terms of both the exciting science questions LISA will address and the remarkable technology that will enable this.

AdvoReach co-chairs: Martin Hendry (University of Glasgow, UK)
Kelly Holley-Bockelmann (Vanderbilt University, US)
Five pillars of LISA AdvoReach

- Public relations
- Advocacy
- Outreach
- Education
- Internal Comms
“LISA” papers: 1990-2019
Total number: 1409

“LIGO” papers: 1990-2019
Total number: 1619

Total number of citations: 13,543

Total number of citations: 24,022
OUTREACH RESOURCES

This page collates a number of outreach resources for LISA Pathfinder

CONTENTS OF THIS PAGE

Launch-related material
LISA Pathfinder mission brochure and ESA Bulletin article
Social media: twitter
Posters
ESA image & video archive
Videos from the LISA community
ESA Euronews and ESA TV
Other websites

LAUNCH-RELATED MATERIAL

Video footage of launch.
Launch replay - extended, with commentary.
ESA media kit for LISA Pathfinder.
Arianespace press kit for launch.

Schedule for launch event on 2 December 2015, including details of live streaming.

Update 2 December: The launch of LISA Pathfinder has been postponed to 3 December. Updated launch schedule and live streaming details.
<table>
<thead>
<tr>
<th>Videopreview</th>
<th>Title</th>
<th>Media Description</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image" alt="Video" /></td>
<td>The path to LISA: a unique collaboration</td>
<td>The LISA Pathfinder mission, which demonstrated key technologies for the LISA...</td>
<td>Jun 05, 2019</td>
</tr>
<tr>
<td><img src="image" alt="Video" /></td>
<td>The path to LISA: LISA Pathfinder was a lab in space</td>
<td>LISA Pathfinder, the test mission for LISA, the planned gravitational-wave observatory in...</td>
<td>Feb 22, 2019</td>
</tr>
<tr>
<td><img src="image" alt="Video" /></td>
<td>The path to LISA: The interferometers of LISA and LISA Pathfinder</td>
<td>The LISA Pathfinder mission and LISA, the planned gravitational-wave observatory in...</td>
<td>Nov 07, 2018</td>
</tr>
<tr>
<td><img src="image" alt="Video" /></td>
<td>The core of LPF and LISA - free falling test masses</td>
<td>At the core of the LISA Pathfinder mission and at the core of LISA, the planned...</td>
<td>Aug 02, 2018</td>
</tr>
</tbody>
</table>
Activities for educating junior LISA scientists
Fumiko Kawazoe

• 5 lectures on LISA science were offered during the AEI lecture week in 2018
  • Compact binaries, MBH cosmic growth,
  • Probing MBH binaries with LISA and pulsar timing, etc.

• A joint topical workshop is planned by Urbino and AEI Hannover
  • In 2019 in Urbino
  • On Astroparticle physics and GW astronomy
advoreach@lisamission.org

advoreach-
chairs@lisamission.org
Education And Public Outreach Efforts by Pulsar Timing Array Collaborations

Jeffrey S Hazboun

Funded under NSF Award 1430284

Image Credit: Tonia Klein
EPO Pyramid

Create a professional work environment that encourages inclusion, by respecting and valuing diversity

Train next generation of STEM employees through advanced level education and research

Build pipeline of interested students and involve them in research activities

Engage people in science topics and keep them informed

Excite people about our research

Train

Educate

Engage

Inform

Inspire

Image Credit: Kristina Islo, Joey Key, Tonia Klein, Joseph Swiggum
Catching Gravitational Waves With A Galaxy-sized Net of Pulsars,
-Steve Taylor

In the five decades since Jocelyn Bell-Burnell’s discovery of the first pulsating radio star—a pulsar—we now know of at least 2409 such objects in our Galaxy. Many of these lighthouse-like interstellar beacons are active not only at radio wavelengths, but across the electromagnetic spectrum: for example, the Crab Pulsar emits about thirty flashes per second even in optical light. Short rotational periods, usually on the order of one second or less, constrain these energetic objects to have diameters of about 10 km. The only state of matter known to remain stable under such high centrifugal forces is nuclear matter. In other words, pulsars are enormous, rapidly rotating atomic nuclei! Such an exotic state of matter—known as a neutron star—is consistent with predictions that supernovae should leave compact remnants behind. The Crab pulsar is the Holy Grail of the supernova-neutron star connection: the pulsar sits right in the middle of the Crab Nebula, associated with the Crab Supernova of 1054.

Figure 1: The NRAO Robert C. Byrd Green Bank Telescope in West Virginia (top) and the 35-m William E. Gordon Telescope at Arecibo Observatory in Puerto Rico (bottom). From greenbankobservatory.org.
Space Public Outreach Team (SPOT)

- NANOGrav SPOT Manager: Jessica Page, UAH (jp0089@uah.edu)
- Nanograv-epo.slack.com (#spot) Slack channel for discussion/coordination
- Slides and advertising materials kept up to date on the document database

Image Credit: Joseph Swiggum
Pulsar Search Collaboratory (PSC)

- Currently, 500 high school students, 58 teachers, and 35 undergraduate students from 56 schools across the country.
- PSC mentors training
- Spring online training
- WVU Capstone event
- PSC camp at Green Bank
- PSC 3-credit extension course for high school students offered at WVU.

Co-funded by NSF award numbers 1516512 and 1516269

*See C8 Tues 1: The Pulsar Search Collaboratory, Kathryn Williamson*
Metronome PTA demonstration

Lam, Romano, Key, Normandin and JSH
American Journal of Physics 86, 755 (2018); doi.org/10.1119/1.5050190
github.com/nanograv/tabletop_pta
Australian Research Council
Centre of Excellence for Gravitational Wave Discovery

Einstein-First Project

www.einsteinianphysics.com
$1.5M, 5 year international project aiming to create a complete Einsteinian curriculum from Year 3 to Year 12

Einsteinian Physics Education Research Collaboration
Australia-Norway-Germany-Scotland- Korea- China-LIGO Scientific Collaboration
Changing Commonsense

Common sense is the collection of prejudices acquired by age eighteen.

Albert Einstein

1948
<table>
<thead>
<tr>
<th>Schools Today</th>
<th>Modern Understanding</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rigid Euclidean space</td>
<td>Space flexible and curved</td>
</tr>
<tr>
<td>Time is absolute</td>
<td>Relative spacetime</td>
</tr>
<tr>
<td>Light is a wave</td>
<td>Everything combines waviness and bulletiness</td>
</tr>
<tr>
<td>Bullets are particles</td>
<td></td>
</tr>
<tr>
<td>Energy is massless</td>
<td>$E = mc^2$</td>
</tr>
<tr>
<td>Newtonian determinism</td>
<td>Quantum uncertainty</td>
</tr>
<tr>
<td>Gravity: instantaneous force</td>
<td>Gravity: spacetime curvature, speed $c$</td>
</tr>
</tbody>
</table>
Replace implicit or untaught concepts with explicit Einsteinian concepts

What is space?
What is time?
What is light?
What is gravity?
What is matter?

Even without answers, the key question is *How can you measure it?*
Gravitational Waves: perfect vehicle for Einsteinian Physics
Einstein-First Needs People

Advertising and Appointing Postdocs and PhD students

Please spread the word!

Talk to David Blair or Ju Li or Magdalena Kersting
SATELLITE MEETINGS

1. Spanish–Portuguese Relativity Meeting (EREPI92019), July 6, 2019, Valencia (Spain).


3. Gravity: New perspective from strings and higher dimensions, July 16–24, 2019, Benasque (Spain). [Link]>


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