Organizing the international community: issues, open questions, opportunities

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The Landscape Has Changed. Yay!

- GW150914, 151226 has kicked open the door to GW astronomy
- Informs the GW science case for next generation detectors
  - We now know that the universe contains BBHs → low frequency matters
  - We still want to detect binary neutron stars, NSBH, galactic supernovae, isolated pulsars and NS → mid and high frequencies matter
- Multi-messenger astronomy is a key science goal
  - Must be taken into consideration when designing 3rd generation detectors
    - Topologies and site location
- ***My view: The case for proposing upgrades to existing facilities and new facilities housing 3G detectors is both strong and urgent!***
- Why urgent?

Historical Gestation Periods for US GW Detectors

- Initial LIGO
  - » **1983** MIT and Caltech jointly present results of the km-scale interferometer study to NSF. Receive endorsement by NSF committee on new large programs in physics.
  - » **1990** The US National Science Board (NSB) approves the LIGO construction proposal, which envisions Initial LIGO followed by Advanced LIGO.
  - » **1994-1995** Site construction begins at the Hanford and Livingston locations.
  - » **2002** The first coincident operation of Initial LIGO interferometers with the GEO600 interferometer.
  - » **2006** Initial LIGO design sensitivity achieved.
- Advanced LIGO
  - » **1999** The LSC Concept Paper for Advanced LIGO completed.
  - » **2003** LIGO Laboratory submits proposal to NSF for Advanced LIGO proposal.
  - » **2006** NSF conducts review of Advanced LIGO Construction.
  - » **2008** Advanced LIGO Construction is funded by NSF.
  - » **2014** Advanced LIGO Construction completed.
  - » **2015** Advanced LIGO begins science operations

Historical Gestation Periods for US GW Detectors

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- Advanced LIGO → 16 years
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Paths to future detectors

- Start with rough estimates of the costs for Voyager, Cosmic Explorer
  - **Semi-Educated Guess for Voyager:** about an Advanced LIGO (in 2016 $)
  - **WAG for Cosmic Explorer:** A new facilities with new detectors: Perhaps an order of magnitude more
- Exploiting sensitivity limits of current facilities (including facility modifications) is the lower cost and nearer term option
  - Supports a ~ 3X improvement over aLIGO using current LIGO facilities
  - Caveat: LIGO Observatories are showing signs of aging and will likely need a substantial refurbishment of the vacuum system in the next 5 years
- A new ‘CE-class’ observatory with 10 or 20 or 40 km arm lengths will require a new site
  - Both Hanford and Livingston are constrained by local development, land ownership, environmental constraints
  - Neither the Hanford or Livingston sites are ‘great’ from an environmental standpoint (seismic, wind, …)
  - Land acquisition issues may ultimately force the US detector to go underground
- Look to the astronomy model – existing observatories produce science whilst new ones are under construction

Considerations in formulating the Global 3G Network

- First generation GW interferometers were independently designed and constructed
  - LIGO, Virgo (joint French, Italian), GEO (joint German, UK)
  - We were competitors at the time
- Second generation GW detectors had some elements of coordination …
  - Advanced LIGO had US, UK, German, Australian contributions
- … but by and large were independently designed and built
- We now collaborate on the analysis of GW data
  - LIGO-Virgo agreement (2007), LV pre-agreement (2013)

- **For 3G, the GW community intends to 'go big'**
- The scale of the project (at least two 10+ km class interferometers) may require coordination across collaborations/projects to take advantage of 'economies of scale'
- Potential advantages of coordination
  - (At least partial) homogeneity in design and construction
  - Coordinated site selection for optimal network design
  - Makes best use of distributed expertise
- Disadvantages of (or perhaps better stated challenges in) coordination
  - Requires establishment of robust management structure, necessitating giving up some control by partners
  - Requires robust system engineering, establishment of standards, interface control, quality assurance program, …
- ***Major challenge may be synchronization of US/European/Japanese plans for 3G upgrades***

What is needed to fund a US 3G detector?

- *Essential* Advanced LIGO must reach its design sensitivity
  - #1 -- because it provides proof that we understand and can tame the noises in 2G interferometers
  - #2 -- it will demonstrate to funding agencies that we can deliver on our design goals
- *Essential* The science case for 3G detectors must be extremely well developed given what we know at the time of the proposal
- *Essential* The community will have to prepare their respective funding agencies that big projects are being planned
  - It can take 5 years to get a project 'queued up' into the NSF Major Research Equipment and Facilities Construction budget
- *Essential* An external evaluation must be conducted by a panel of experts
  - Is the science case sufficiently strong for a 3G detector?
  - Is the technology development mature?
  - Is their preliminary costing and project planning, or is there a path to those?
  - ….
- *Essential* International planning and coordination
  - May be essential for CE-class project
- *Really Important* Support and advocacy from an outside community
  - They support GW science because it adds to their science
  - For the GW community, it's the astronomers, perhaps nuclear physicists

Near Term Need: Coordinated R&D Among the Projects

- R&D themes are common for Voyager and ET/Cosmic Explorer
  - Lower loss coatings
  - Si test masses
  - Longer wavelength stabilized lasers
  - Cryogenics
  - Newtonian Noise
  - Control schemes
  - …
- Currently, the major projects/collaborations do not really ‘inter-collaborate’ on R&D
  - LSC, Virgo, KAGRA each have separate R&D programs; some cross-talk, but little to no coordination
- ‘Coordination’ here is defined as having a common program in which resources (= expertise, person power, funding) are assigned and managed efficiently
  - LSC Instrument Science White Paper is probably the best example of a coordinated R&D effort
- Distinction between ‘R’ and ‘D’ in this model?
- Role of GWIC, role of agencies?