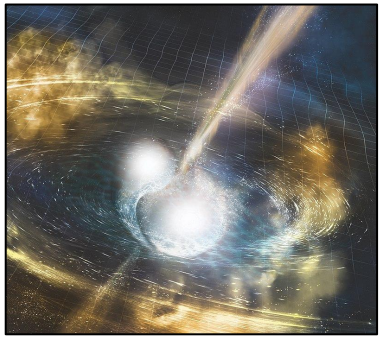
Why do we care about the Multi-Messenger Universe?

Some recent examples from “Multi-messenger” astroparticle physics (APP):



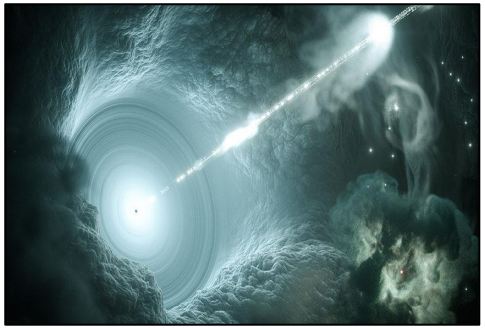
LIGO-Virgo GW detection of binary neutron star collision

Observed also in gamma-rays, optical, IR, UV, X-rays, radio,

Followed up by neutrinos (none found)

Importance:

- Source of r-process elements heavier than iron
- Standard siren measurement of H0
- Tests of GR, ruled out some GR-alternatives



IceCube detection of 290 TeV muon neutrino from blazar

Observed also in in radio, IR, optical, X-rays, gamma-rays

Importance:

- Blazars as sources of high-energy neutrino flux and also cosmic rays

Goal: combine observations from GWs, Gamma Rays, EM, neutrinos, cosmic rays with theoretical modeling

4. The Netherlands support the proposal as is put forward by CERN and APPEC to establish a network of European institutions active in theoretical astroparticle physics with the central hub positioned at CERN.

- Theoretical astroparticle physics
  - Very broad - should a few research lines be supported over others?
  - CERN Fellowships/Associateships/Staff positions to APP theorists?
  - Very close to astronomy?
- At CERN
  - Will APP scientists have offices at CERN? Or will CERN just act as hub for meetings/workshops/etc?
  - Would APP scientists be too isolated?
  - What other types of support could CERN offer?
  - Who currently at CERN would talk to APP scientists or astronomers?

14. Given that (a) signs for new physics may come from the field of astroparticle physics and gravitational wave physics and (b) the community is internationally growing, CERN should widen its physics palette and welcome the housing/support of APP experiments. CERN's governance is well-suited and profitable for these experiments: involvement in Einstein Telescope is a concrete possibility.

- What does housing/support imply?:
  - Recognized experiment? Office space, meeting rooms?
  - Secretarial support? Access to engineering and workshops? Computing resources?
  - Role for CERN bodies in scientific review and assessment procedures?
  - CERN role in acquiring/managing funding of experiments?
  - CERN as full-blown member of APP experiments?

15. The Netherlands support the “Physics Beyond Colliders” diversity program at CERN and we encourage CERN to continue the fruitful collaboration with Fermilab on DUNE, as started recently with protoDUNE.

- Physics Beyond Colliders
  - EDM, NA60/61/62, SHiP, DIRAC, NuSTORM, MATHUSLA, and many more
  - How important in LHC era? How much can CERN sustain?
- DUNE: neutrino oscillations Fermilab-SURF
  - CERN is member in US-based experiment
  - First 10 kton module ready 2023, beam in 2026
  - Not many people, but big role in design/construction cryostat and DAQ
  - Significant money
  - A model to be used more often elsewhere? At what costs?

Some ideas related to GWs...

Searching for sub-solar mass primordial black holes (LIGO/Virgo/ET ++)

- Constraints on fraction of dark matter in primordial black holes

Searching for ultralight bosons (dark photons, QCD axion, axion-like particles) with spinning black holes (LIGO/Virgo/ET/LISA ++)

- Detection/constraints for scalars with mass in $[10^{-19}, 10^{-15}]$eV and $[10^{-14}, 10^{-11}]$eV

Testing General Relativity with GW signals (LIGO/Virgo/ET/LISA ++)

- Mass of graviton, spacetime dimensions, constraints on modified theories of gravity

Neutron star mergers detections and signal properties (LIGO/Virgo/ET ++)

- Possible appearance of a hadron-quark phase transition in the interior region of the produced HMNS/SMNS

Echoes from GW signals (LIGO/Virgo/ET ++)

- Probe of quantum gravity

Lots more...

Some ideas related to GWs...

The Einstein Telescope (ET):

- ET construction, operation, running for ~40 years, cleanup (~5.5 billion)
- In conjunction with Cosmic Explorer and other 3G detectors (~20 billion)
  - Who could possibly govern a multi-billion euro project on the global scale?
- Technical: we need vacuum infrastructure, underground construction, cryogenics, controls
  - Build up expertise from scratch with taxpayer money?
  - Or use existing CERN-based experience/resources?