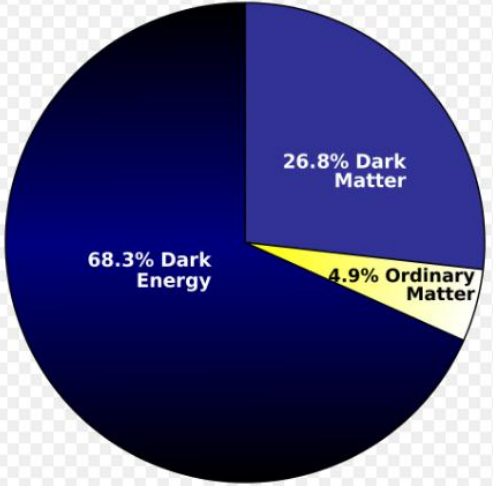
searching for dark photon with Gravitational Wave Detectors

Dark photon

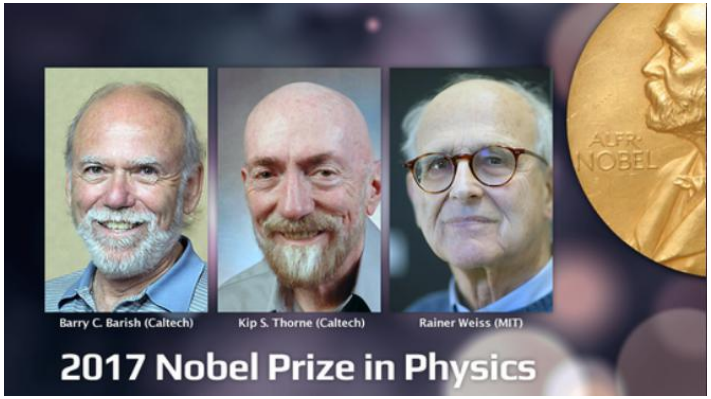


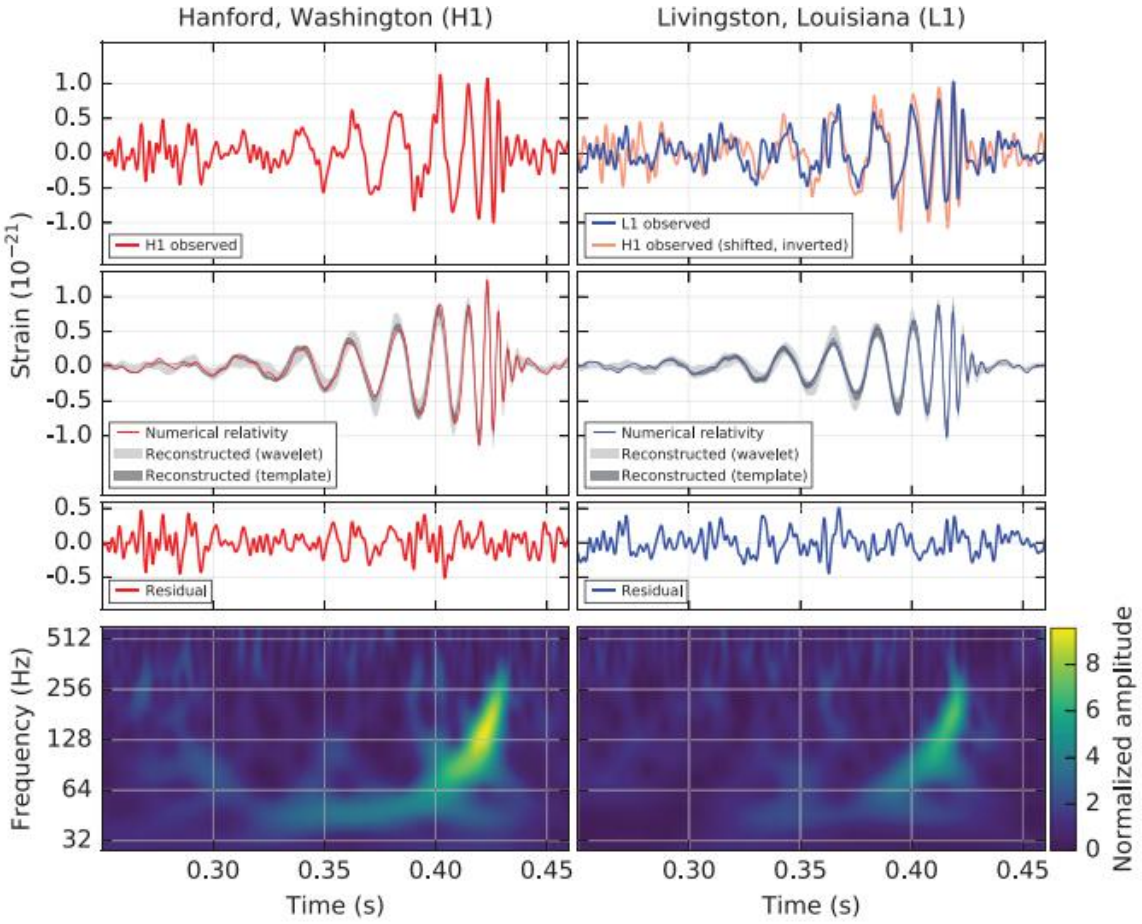
- Dark matter makes up the nominant form of matter in the universe, but the properties of the particles that compose it remain unknown.
- if the dark matter particle is a gauge boson, it is usually denoted as dark photon
- dark photon is one of the promising candidates for the dark matter.

low mass dark photon

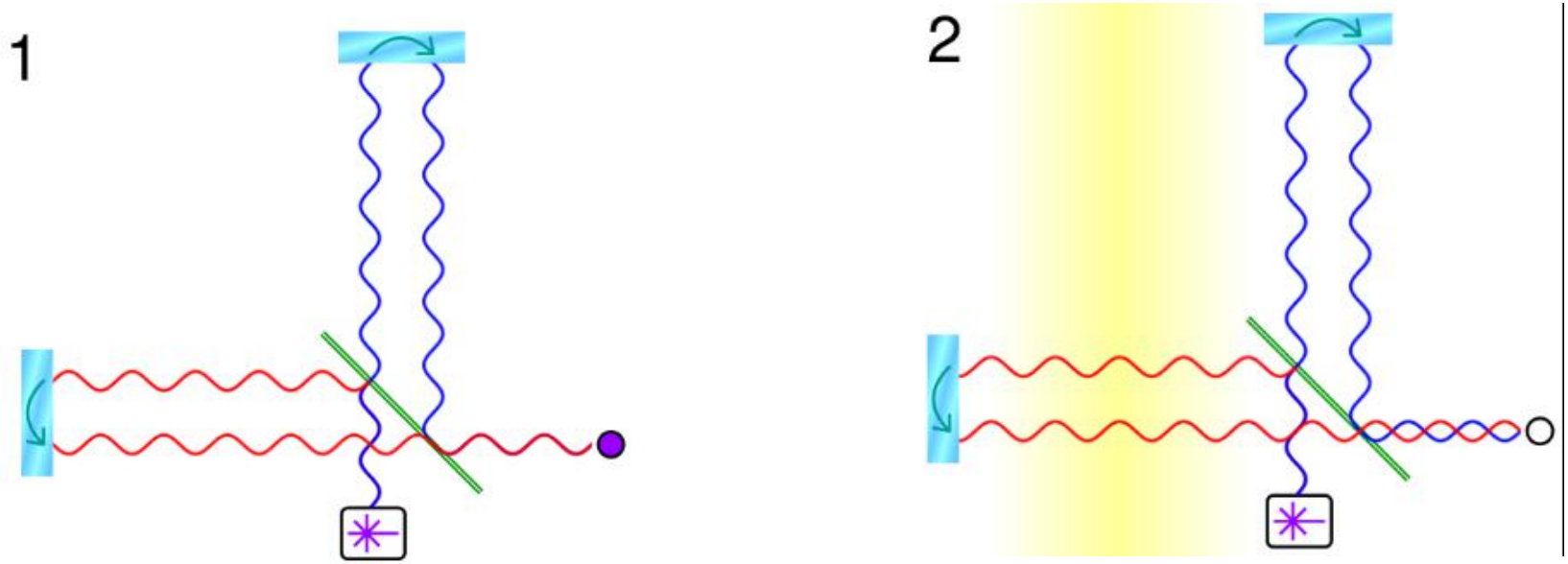
- when dark matter is very light, its local occupation number is numch larger than one.
- It could be treated as a coherently oscillating background field with oscillation frequency determined by its mass.
- dark photon therefore imparts external oscillating forces acting on objects carrying non-zero dark charge.

LIGO experiment





LIGO experiment



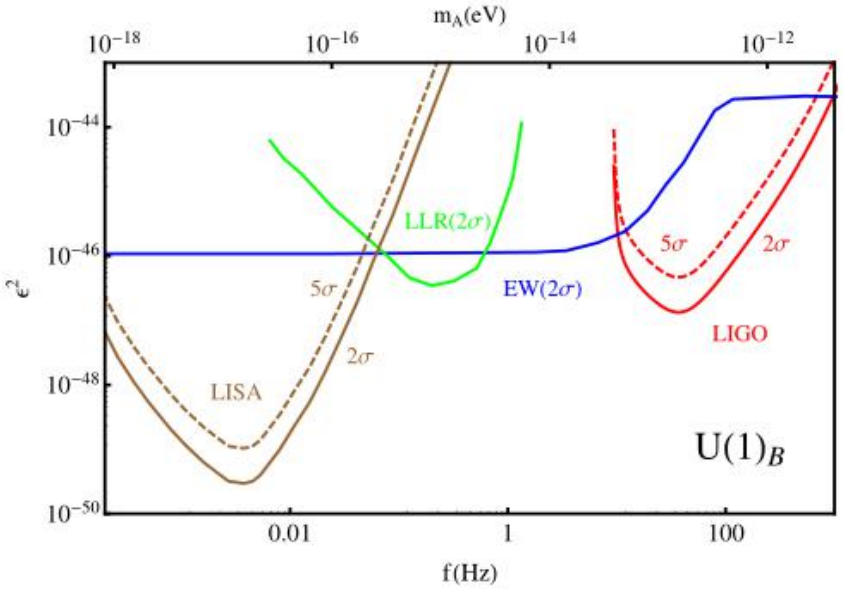
Simplified operation of a gravitational wave observatory

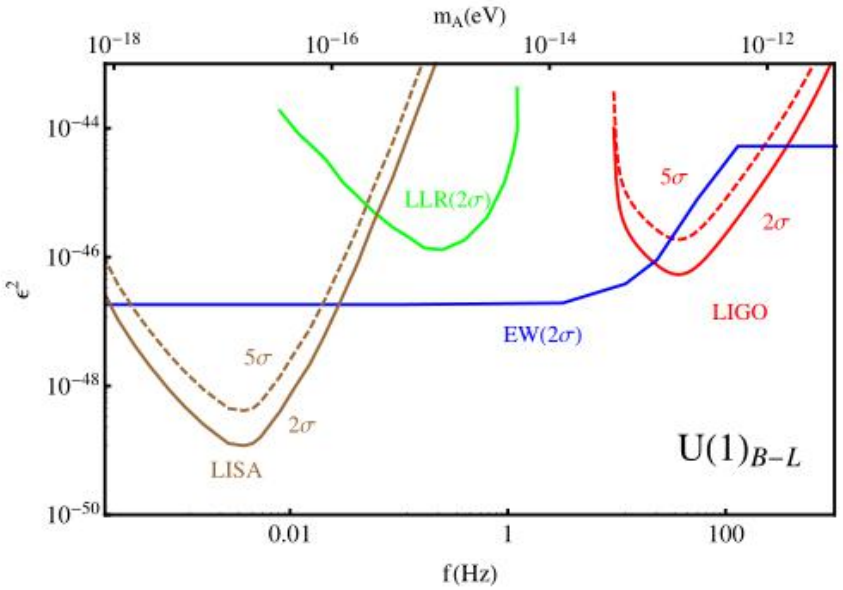
- **Figure 1**: A beamsplitter (green line) splits coherent light (from the white box) into two beams which reflect off the mirrors (cyan oblongs); only one outgoing and reflected beam in each arm is shown, and separated for clarity. The reflected beams recombine and an interference pattern is detected (purple circle).
- **Figure 2**: A gravitational wave passing over the left arm (yellow) changes its length and thus the interference pattern.

dark photon and LIGO

- LIGO opened the era of Gravitational waves astronomy.
- The relative displacements of the test masses(interferometer mirrors) may be generated not only by the passage of GW, but also by a dark photon background.

predicted result





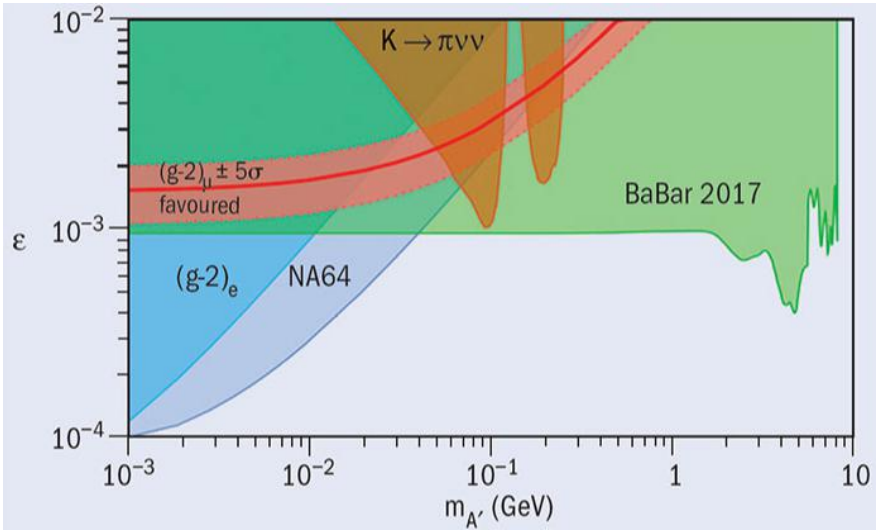


FIG. 1: The 2σ exclusion limit and 5σ discovery potential obtained from LIGO and LISA after 2 years of running for B (upper) and $(B-L)$ (lower) dark photon dark matter. Coupling strength is normalized to EM coupling strength, i.e. $\epsilon^2 = \alpha/\alpha_{EM}$. The blue and green curves are limits from the Eöt-Wash (EW) experiment [6, 7] and the Lunar Laser Ranging (LLR) experiment [8–10].

Thanks