The Next Thirty Years of Gravitational Wave Astronomy

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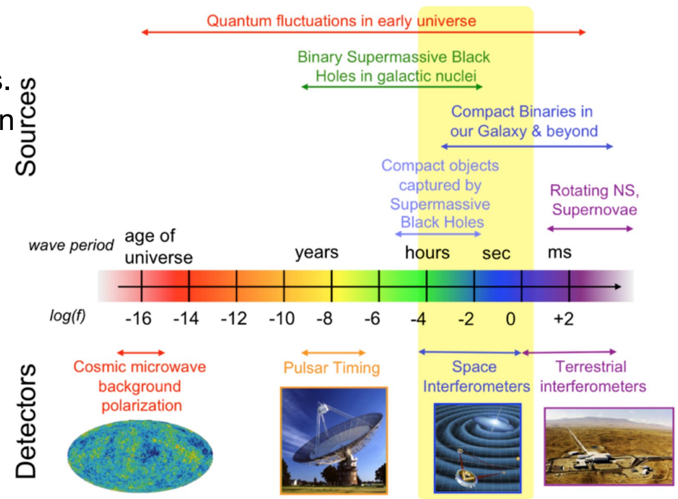

Observing the universe in the Gravitational Wave spectrum offers tremendous potential for astrophysics. Gravitational wave observations can provide insight on precisely those questions that are most difficult to address with electromagnetic observations such as the nature and behavior of "dark" objects and the history of the universe prior to the time of last scattering. Figure 1 shows a schematic illustration of the spectrum of observable gravitational waves, spanning nearly twenty decades in frequency from inverse Hubble times to kilohertz. As with the electromagnetic spectrum, different sources are expected (top of figure) and different instrument technologies are needed (bottom of figure) in each frequency band. The millihertz band is highlighted because it contains a rich variety of sources and because it is uniquely accessible by space-based instruments - much like the X-ray, gamma-ray, and far-IR bands of the electromagnetic spectrum. Over the next thirty years, the following developments in gravitational wave astronomy are anticipated:

- **Ground-Based Interferometers in the 1Hz- 1kHz band:** 2nd-generation instruments currently under construction make the first positive detections within the next 5 years and produce significant scientific results in the areas of compact binaries, gamma ray bursts, and supernovae. In a world-wide effort (US, Europe, Japan, India, China), the detector infrastructure then increases both in number and sensitivity as technologies such as squeezed-light, cryogenics, and underground instruments are incorporated.
- **Space-Based Interferometers in the milliHertz band:** A LISA-like instrument flies in the late 2020s, providing the first glimpse into the millihertz band and access to the associated science. In addition to the US and Europe, a 1st-generation instrument might involve Japan (DECIGO) or possibly China. Follow-on instruments push sensitivity, bandwidth, and 'imaging' capabilities to improve on the scientific output of the first-generation instrument.
- **Pulsar Timing arrays in the nanoHertz band:** Detections of a stochastic astrophysical background and possibly isolated sources occur on a similar time as the ground- and space-based detections. Sensitivities continue to increase as additional pulsars are discovered and characterized, instruments improve, new facilities come online (e.g. SKA) and observations of existing pulsars accumulate.
- **CMB polarization and cosmological GWs:** Suborbital and orbital CMB polarization instruments will either confirm the existence of or provide a constraint on an inflationary GW background. These results may help guide the development of direct-detection instruments for GW backgrounds.