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Multi-frequency GW astronomy

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Discoveries of binary black holes (BBHs) and binary neutron stars via gravitational waves (GWs) opened a new window to explore the universe. So far the GW astronomy is accessible between about 25 Hz up to 2000 Hz (by LIGO and Virgo detectors on Earth). Compact objects such as neutron stars and black holes with masses around O(1) - O(100) Solar masses are main sources in this frequency range. There are international efforts for GW observations in multi- frequency bands, in particular toward lower frequencies. For example, Pulsar Timing Array aims to detect gravitational waves in nanohertz, targeting supermassive black hole binaries. The success of the LISA Pathfinder mission of ESA (European Space Agency) proved that the technology required to detect GWs around millihertz or below in space is feasible. One of the most important information we can obtain by the multi-frequency GW observation would be the formation and evolution of compact objects in binaries, in particular BBHs, over the cosmic time. The “middle-frequency” range between 0.1-10 Hz have attention recently for the prospects of discovering intermediate-mass black holes. In addition to resolved targets, cosmic GW background calls for a broad-band or multi-frequency observation. In this review talk, I will present highlights of different proposals targeting different frequency bands and their science goals. The “multi-messenger”astronomy, in coordination with particle and electromagnetic-wave observations, will be most powerful when multi-frequency GW observations will be available. I will discuss prospects of multi-frequency, multi-messenger astronomy that would be in reality in decades, focusing on black hole astronomy and cosmology.

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