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The Search for Gravitational Waves with the NANOGrav Pulsar Timing Array[1]

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Pulsar timing arrays (PTAs) are kiloparsec-scale, nanohertz-frequency gravitational wave (GW) detectors composed of millisecond pulsars (MSPs) timed over many years. Correlated variations in PTA MSPs' pulse arrival times that are consistent with a quadrupolar signature indicate the presence of a GW signal in the timing residual data. A GW background (GWB) produced by a population of coalescing supermassive binary black holes (SMBBHs) is expected to be the first GW signal detected by PTAs, with continuous-wave (CW) detections of one or more individual SMBBHs expected within the next 5-10 years; other potential sources include SMBBH mergers, cosmic strings, and inflation-era relics. Detection and characterization of GW sources by PTAs requires timing many tens of MSPs positioned across the sky, with timing precisions of tens to hundreds of nanoseconds, over timing baselines of years to decades. In this talk, I will focus primarily on the North American Nanohertz Observatory for Gravitational Waves (NANOGrav), as well as the International Pulsar Timing Array (IPTA). I will describe the construction of these PTAs' data sets and will review recent results from their GW analyses, in particular the common spectral process detected in 12.5 years of NANOGrav data collected with the Arecibo Observatory (AO) and Green Bank Telescope (GBT). Whether this signal is the first hint of a GWB will be determined with near-future NANOGrav (15-year) and IPTA data sets. I will also describe the continual expansion of these PTAs, through instrumentation upgrades and pulsar surveys, in order to increase their GW sensitivity. Finally, I will discuss plans for the NANOGrav array in the wake of the tragic loss of Arecibo, especially the crucial role of the GBT in the coming years; the potential use of the next-generation VLA (ngVLA) for PTA observations; and the Deep Synoptic Array 2000-antenna (DSA-2000) interferometer, which will transform the field of low-frequency GW astrophysics.

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