Fundamental and Gravitational Wave science with Pulsar Timing

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Outline

1) Introduction to **Pulsar Timing**
2) **Fundamental Physics**
3) **Gravitational Waves**
4) Conclusions
Pulsar

Rotation axis

Radiation beam

Magnetic field lines

Radiation beam

Credits: M. Kramer
Timing

- Pulsar with companion
- Interstellar medium
- Solar System
- Other pulsar
- Radio telescopes on Earth

Gravitational Waves from supermassive black hole binaries
Testing GR – double pulsar

Kramer et al. 2006
Equation of state – heaviest pulsar

Cromartie et al. 2019
Some of the previous contenders

Demorest et al. 2010
Gravitational Waves

Gravitational Waves from supermassive black hole binaries

Interstellar medium

Pulsar with companion

Other pulsar

Radio telescopes on Earth

Solar System

Gravitational Waves

Pulsar with companion

Interstellar medium

Other pulsar

Solar System

Radio telescopes on Earth
Gravitational Waves

Credits: SKA
GWB Upper Limit

Pessimistic [e.g. Sesana et al. (2016)]
Moderate [e.g. Simon & Burke Spolaor (2016)]
Optimistic [e.g. McWilliams et al. (2014)]

Arzoumanian et al. 2018
GWB Astrophysical Constraints

Chen, Sesana, Conselice 2019
International Pulsar Timing Array

Green Bank
Arecibo
NANOGRAV
EPTA
(5 radio telescopes)
InPTA
Indian Pulsar Timing Array
FAST
MeerKAT
Parkes
PPTA
IPTA second data release

Perera et al. 2019
Conclusions – Pulsar Timing

1) Fundamental Physics:
   – Tests of GR with pulsar + companion mass measurements
   – EOS constraints with heaviest pulsar

2) Gravitational Waves:
   – SMBHBs and galaxy merger constraints
   – constraints on exotic objects

3) Other Physics: neutron star studies, radio pulse emission, ISM, Solar System, etc.