Contribution ID: **69** Type: **Short talk**

Fundamental and Gravitational Wave Science with Pulsar Timing

Monday 11 November 2019 15:55 (15 minutes)

Since the discovery of pulsar 50 years ago, they have proven to be very useful astronomical objects. Spinning neutron stars with a very stable rotation period as low as a few milliseconds, emitting radio pulses, similar to a lighthouse. These periodic radio signals can be detected and timed on Earth with an accurate timing model describing the entire process from emission at the pulsar through its travel through the interstellar medium and the solar system to Earth. A very large number of different effects can be measured. I will give a brief overview on the science of Pulsar Timing with a focus on fundamental and gravitational wave science.

With the emission process we can study the properties of the neutron star itself. The timing model is very sensitive to the masses if the pulsar is in a binary with another object. This allows us to put very tight constraints on the mass of the neutron star itself and by extension put some meaningfull limits to the equation of state of neutron stars. Some binary system can be very extreme, like a double pulsar system, and thus are a very great system to test General Relativity and alternative theories.

The path that the photons travel between pulsar and Earth can be up to about a thousand of lightyears, this is similar to having a galactic scale detector for gravitational waves (GW) and other interstellar medium effects. The most likely source of GW are supermassive black hole binaries, which create both a stochastic background as well potential single sources affecting all pulsars in a characteristic fashion. Other interesting sources could be GWs from burst of memory events, cosmic string loops and primordial black hole binaries. To disentangle noise from one pulsar, we need to look at many pulsars and look for common processes. This is what Pulsar Timing Arrays do to look for Gws.

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Session Classification: Short talks