OBSERVATIONAL PULSAR ASTRONOMY

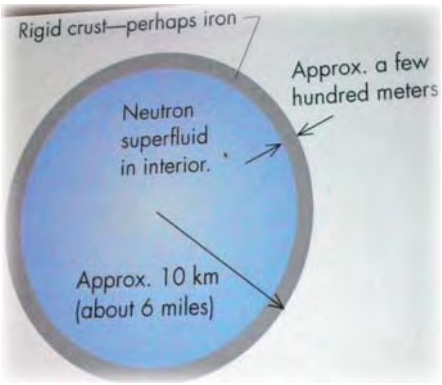
A talk by Dr Ramesh Bhat, Centre for Astrophysics and Supercomputing, Swinburne University of Technology

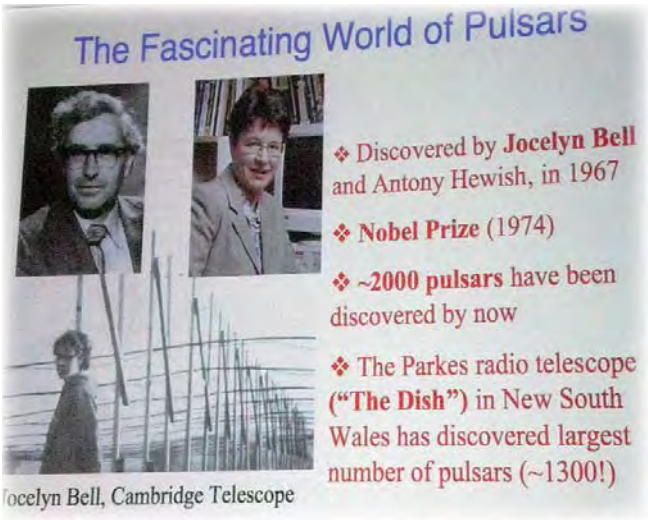
Dr Bhat divided his presentation on Pulsar Astronomy into three parts:

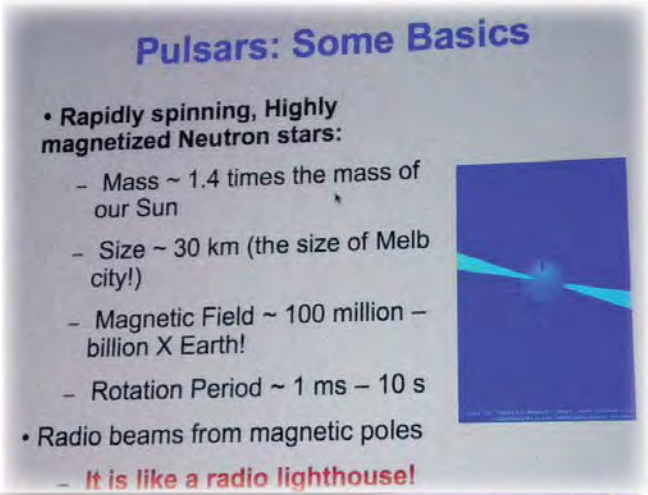
- The fascinating World of Pulsars,
- Gravitational Waves,
- Timing Array Programs.

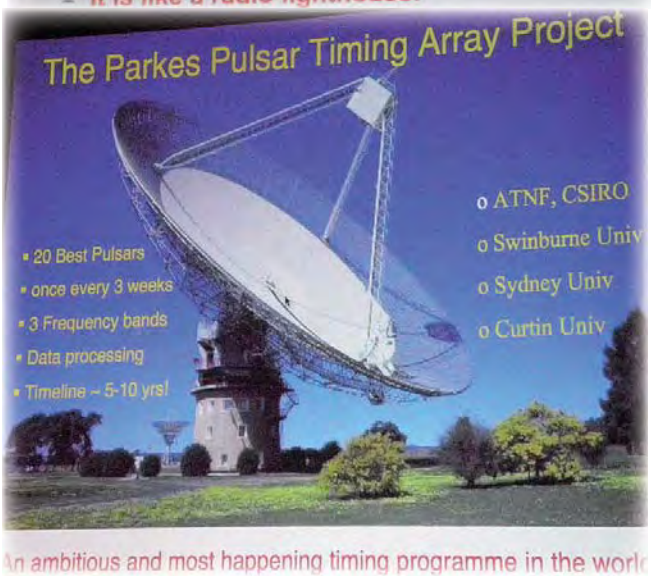
Dr. Ramesh Bhat

Pulsars (portmanteau of pulsating star) were first identified by Joselyn Bell and Antony Hewish in 1967 who, for lack of a definitive source for the signal at that time referred to it as LGM (Little Green Men). By now over 2000 of the Pulsars have been discovered. A pulsar is a highly magnetized, rotating Neutron Star that emits a beam of electromagnetic radiation. This radiation can only be observed when the beam of emission sweeps past the Earth, much like the way a lighthouse can only be seen when the light is pointed in the direction of an observer,which is responsible for the pulsed appearance of the emission. Neutron Stars are extremely dense with short rotational periods producing very precise pulses with periods that range from roughly milliseconds to seconds. The precise periods of pulsars makes them useful astronomical tools, with some types of pulsars rivalling Atomic Clocks in their timekeeping accuracy. Careful observations of a binary neutron star system discovered some 10,000 light years away and monitored with the 64metre Parkes Radio Telescope for six years, has shown for the first time convincing evidence for the effect of Gravitational Radiation: the stars' million-kilometre orbit had shrunk in that period by 4.2 metres. ‘We at Swinburne University of Technology’ Dr Ramesh Bhat explains, ‘have used this "odd couple"of stars to confirm with astonishing precision that Albert Einstein's General Theory of Relativity (now almost a century old) still provides a pretty accurate explanation of the universe as we know it. With such observational proof we don't see any need to modify the General Theory of Relativity...' Einstein's theory explains gravity as aproperty of the geometry of space and time. It has passed all experimental tests since 1916 with complete success, making it one of the most durable theories in modern physics [see Einstein]. The detection of Gravitational Waves has a long and chequered history. The concept is simple: Accelerating masses in space-time produce ripples in the fabric of space that propagate



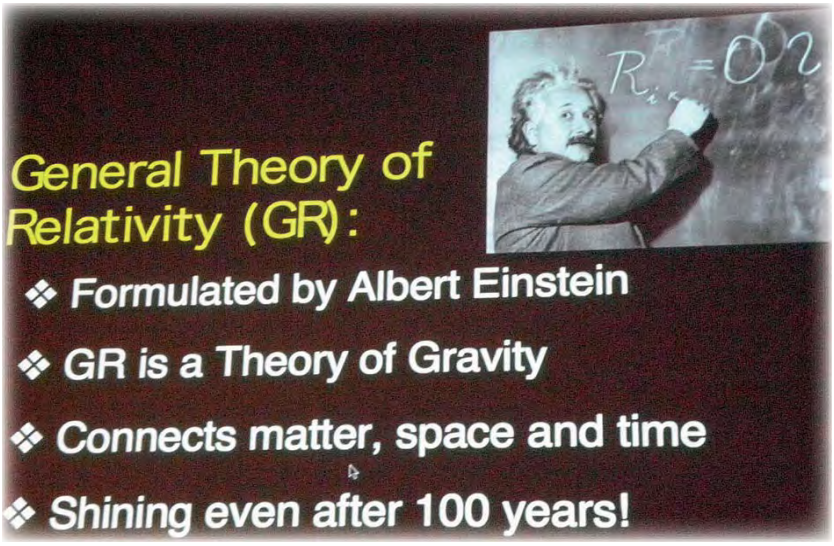






at the speed of light through space-time and cause a suspended pendulum to oscillate as the ripples wash past. Yes, the concept is simple. Thenwhy can't we find them? The first generation detectors (pendulums) were massive cylinders of temperature controlled aluminium suspended in a vacuum chamber. They measured everything from Earth tremors to traffic on the highway to ocean waves crashing on shore, but no gravity waves; no coalescing Neutron Stars, no merging galaxies. Monitoring of the Hulse-Taylor Binary already seemed to confirm the existence of gravity waves. But calculation of a typical gravitational wave amplitude resulting from this here on Earth gives the unimaginably small figure of 10^{-26}m. The current LIGO installations around the globe (4km x 4km Laser Interferometer Gravitational Wave Observatories) are about one magnitude away from the sensitivity needed for detecting this.

A Laser Interferometer Space Antenna (LISA) is a planned space mission to monitor fluctuations in the relative distances between three spacecraft, arranged in an equilateral triangle with 5 million kilometre arms in an attempt to increase sensitivity to the required level. LISA was originally conceived as a joint effort between the United States space agency NASA and the European Space Agency ESA. However, funding of the project has not been confirmed.



Many points were raised during question time, ranging from alternate Gravitational Theories to General Relativity to the propagating speed of Gravity Waves, and the possibility that their effect on space-time may not be measurable with the current time / space dependent approach.

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