The best clocks in the cosmos

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In the 24th February 1968 issue of Nature, the prestigious British journal of science, there appeared a paper which opened up a new field of astronomy which has flourished since then.

The story behind this paper goes back to 1967 when Antony Hewish and his research student, Jocelyn Bell Burnell, of Cambridge University were analysing the radio signals received from outer space. Jocelyn found a series of equally spaced radio pulses each about 0.04 seconds long and having a strikingly regular periodicity of about 1.34 seconds.

Given that such a sequence of radio signals had never before been seen from any known cosmic source, Jocelyn even thought that these could be signals from extraterrestrials trying to contact us.

In fact, she toyed with the idea of naming the radio source from which the signals originated as LGM-1 which is an acronym for "Little Green Men-1"! Of course, the truth was less exciting than the discovery of extraterrestrial intelligence but opened up an entirely new vista of exploration in astronomy.

We now know - as was pointed out first by Thomas Gold and Franco Pacini in 1968 - that these radio signals come from pulsars which are rapidly spinning neutron stars. They occur as a possible end state in the evolution of massive stars when gravity crushes the matter in the stellar core to a very compact size and to a density as high as within an atomic nucleus. A typical neutron star will have a mass comparable to that of the Sun compressed to a sphere of radius less than a few kilometres and will be made of mostly neutrons. It will be spinning rapidly and will emit beams of radio waves which will sweep around the sky as the star rotates.



What Antony and Jocelyn picked up were the radio signals from one such source. The existence of neutron stars was predicted as early as 1933 but it remained a theoretical dream till their discovery in 1967. Very soon, more such pulsars were found and today we have a rich sample of hundreds of them. Antony Hewish received a Nobel Prize in 1974 for the discovery of pulsars though, unfortunately, Jocelyn Bell was left out.

Two features make pulsars quite useful. First, they act as remarkably stable clocks with a very precise beaming pattern for the radio waves. The waves received from a given pulsar are almost like its signature. Second, they have a very strong gravitational field in their vicinity which needs to be described by Einstein's general theory of relativity.

Having such a stable clock in a strong gravitational field allows one to study fairly extreme physical conditions and conduct precision tests of general relativity. Such an investigation led to an indirect proof of the existence of gravitational waves in a binary star system, containing a pulsar as one member. These studies led to a Nobel Prize for its discoverers, Joseph H. Taylor and Russell A. Hulse, in the year 1993.

(NEXT WEEK: Catching Uranus: Saga of missed opportunities)

Astrophysician Jayant Narlikar and Thanu Padmanabhan, theoretical physicist, will contribute to **DNA**'s *special series through 2009, designated the International Year of Astronomy.*