Pulsars

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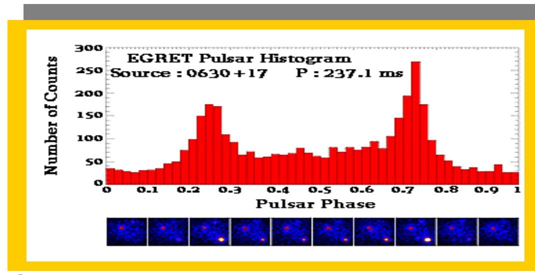

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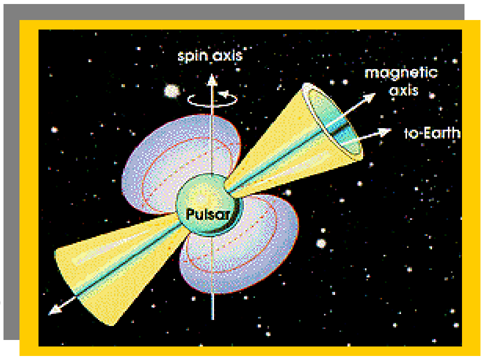
Geminga Pulsar

In the late 1960s a graduate student studying some data from a radio telescope noticed an odd point-like source of radio emissions that seemed to be blinking on and off regularly. Several astronomical objects were known to put out radio waves. All of these sources were either constant over thousands or millions of years, like the sun and "active" galaxies, or were sporadic or one-time events, like an explosion. These new signals were regularly timed "beeps". At the time, the only known regular radio signals were created by humans. This sparked a lot of debate about whether these blinks might be deliberate transmissions from some kind of intelligent aliens.

Several more examples of blinking radio signals were soon identified. The slowest example blinked at a rate of around once per second. The fastest varied around 30 times per second. Astronomers knew that anything putting out enough energy to blink quickly over interstellar distances had to be very small and dense. Not even a **white dwarf** could do this, so they revisited an idea that had been around for a number of years: a **neutron star**. No good way had yet been devised to positively identify an object as a neutron star. Could a neutron star help to explain these **pulsars** or pulsing stars?

Neutron stars are born of dying moderately-massive stars with strong magnetic fields and a fairly fast rotation (like our sun). Magnetic fields and **spin** (angular momentum) don't just vanish. As the former star's material is compacted into a neutron star, magnetism and spin are also compacted, in a sense. The magnetic field would become more intense, and the spin would become faster, just as figure skaters spin faster when they pull their arms and legs in tightly. Astronomers soon realized several consequences of these facts.

A common characteristic of magnetized objects is that their magnetic fields have weak spots at their north and south poles. More accurately, charged energetic particles and gases can move through the magnetic field much more easily there, since they don't have to cut across the field lines. That's how high energy **protons** and other charged particles move toward the poles of the Earth to make our colorful aurorae. Also, several kinds of astronomical objects, such as newly-formed stars and active galaxies, have been seen to display **bipolar jets**, or high-energy gases squirting out their poles. What if neutron stars had such jets?



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Pulsar Beams rotate like lighthouse beacons

It is also common for objects, for instance the Earth, to have a magnetic pole that does not line up with its rotation pole, or spin axis. The jets coming out of a neutron star do not simply point up along the axis and turn in place. They point out at some angle, and get swept around in a circle with each rotation of the star, like the spotlight from a lighthouse. So if we were located in a direct line of emission, the light would appear to turn on and then off, once per spin. That's exactly how a pulsar appears.

Astronomers have identified over 1000 pulsars. They pulse at all sorts of wavelengths at the same time, including visible light and x-rays, not just radio waves. Pulsars are presently recognized as having the most intense magnetic fields in the universe. They have some of the most intense gravity that we know of short of **black holes**. This makes them natural "laboratories" for studying extreme physical conditions.