Radio Astronomy with Pulsars

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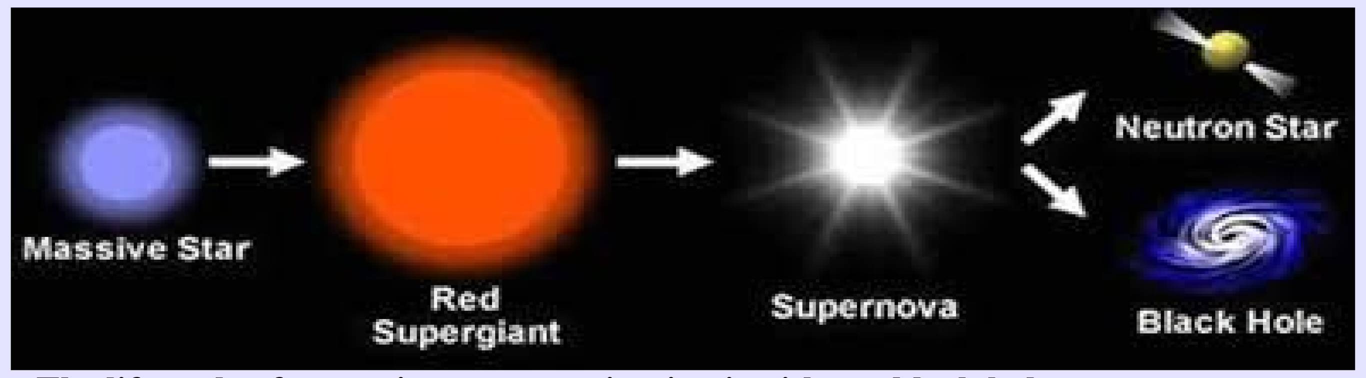
Background

ABSTRACT

Pulsars are the rotating beams of electromagnetic radiation emitted from a neutron star. I have researched the proposal, discovery, function, and importance of pulsars using primary source documents. I have collected data from multiple pulsars and non pulsars by using the Greenbank-20 radio telescope through the Pulsar Search Collaboratory. Pulsars may be used to collect data concerning astrophysical phenomena.

INTRODUCTION

When a massive star (>8 solar masses) has exhausted its fuel and fused all elements leading up to iron, gravity causes the core to collapse to a level beyond the repulsive force of electrons into matter composed entirely of neutrons. The former supergiant is now known as a neutron star.



The life cycle of a massive star, terminating in either a black hole or neutron star.

Neutron stars are much smaller than supergiants, so they spin rapidly to conserve angular momentum. The strong magnetic field accelerates particles which release E/M radiation in a beam focused at the poles rotating with the star, creating a pulsar. [1]

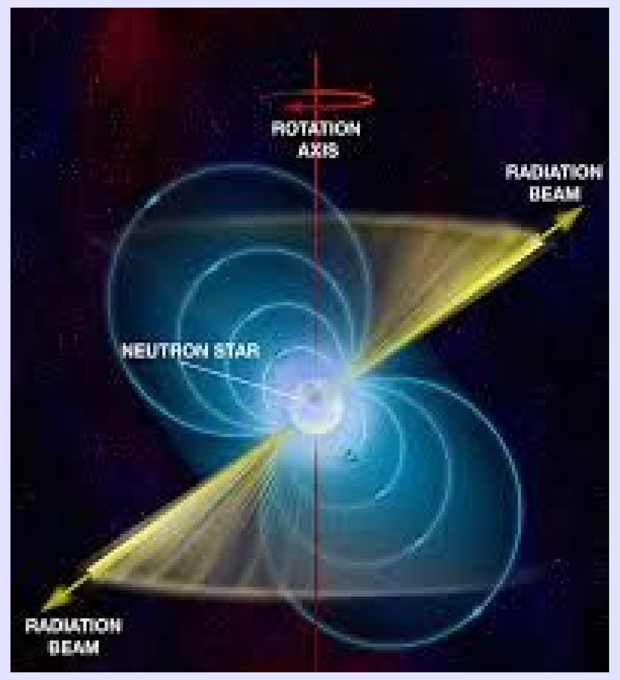
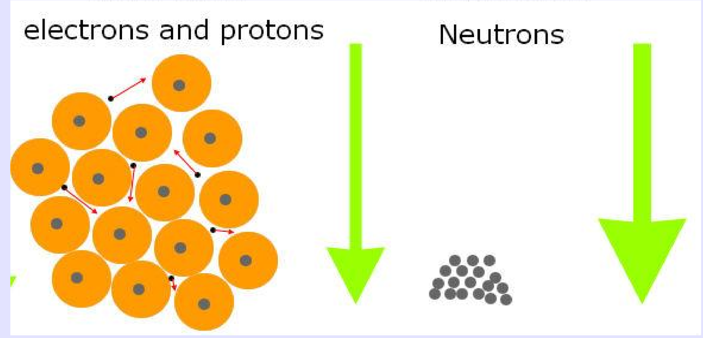


Diagram of rotating magnetic field on a neutron star, creating a pulsar.

Research

ZWICKY AND PACINI

Fritz Zwicky hypothesized that the remnant of a supergiant's collapsed core would be massive enough to overcome electron degeneracy pressure. [2]



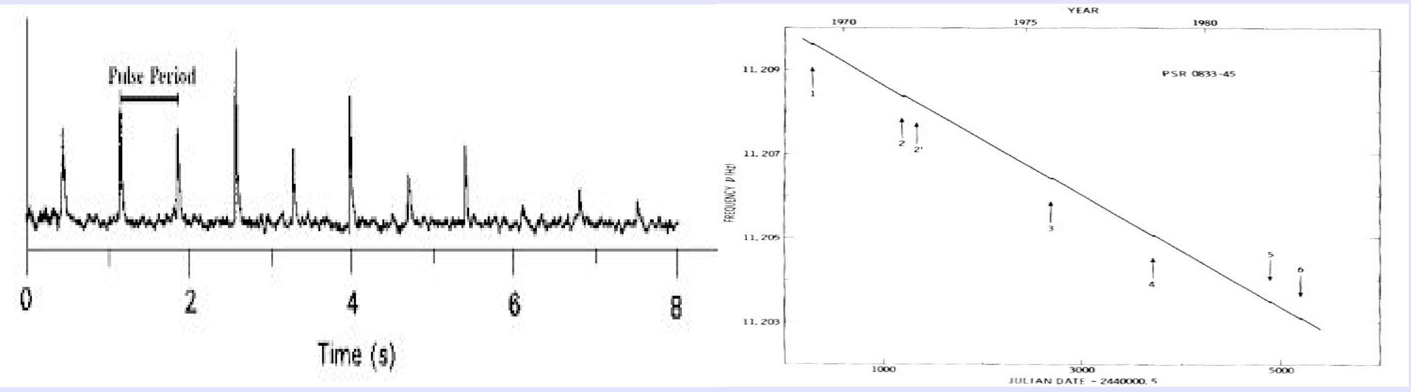
Electron capture results in more dense neutron matter.

Franco Pacini claimed that Zwicky's proposed object must have a considerable magnetic field, and the effects could be observed from earth. [3]

GREENBANK


The Greenbank 120 meter radio telescope located in Greenbank, WV.

By using the Greenbank-20 radio telescope to collect data on celestial bodies, I was able to determine which were strong pulsar candidates, usually characterized by regular period, and constant spin down rate.

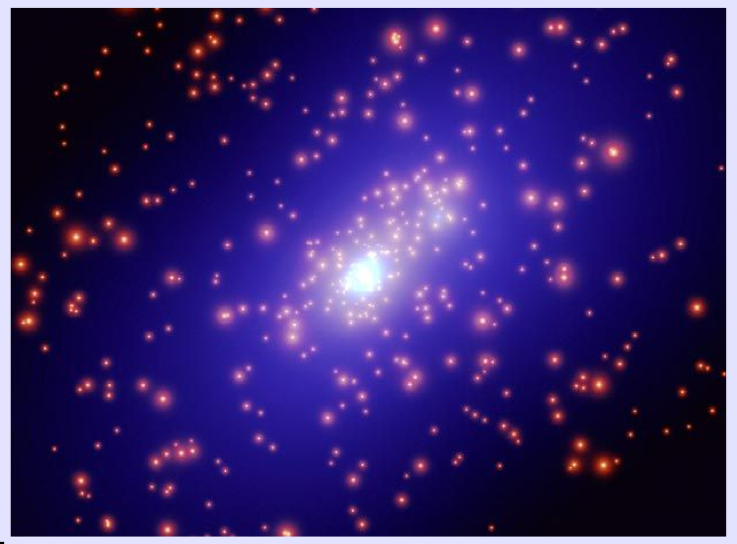


Period (left) and spindown rate (right) of a pulsar candidate.

Applications

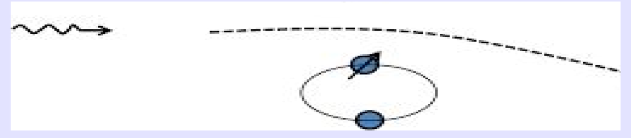
DARK MATTER PROBES

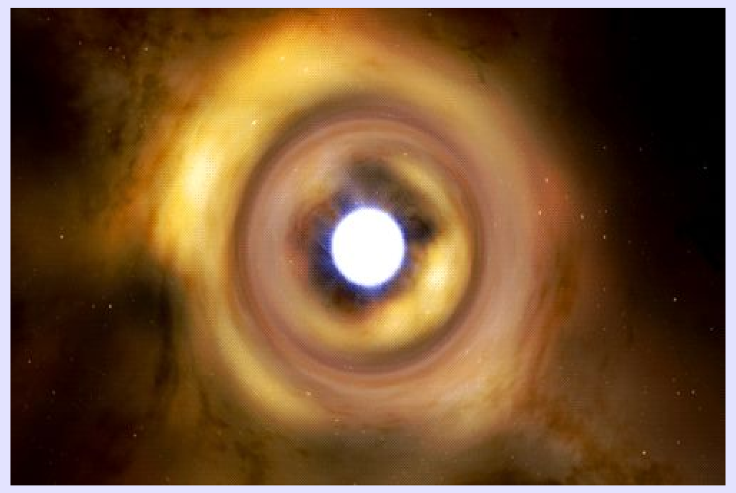
Due to the consistency of their rotational periods, the orbital periods of binary pulsars can be precisely measured. The gravitational effect of dark matter on the orbital period may be directly observed, and used to map density. [4]


Mass map of the Abell 1689 cluster, red objects are not part of Abell.

SPACE TIME PROBES

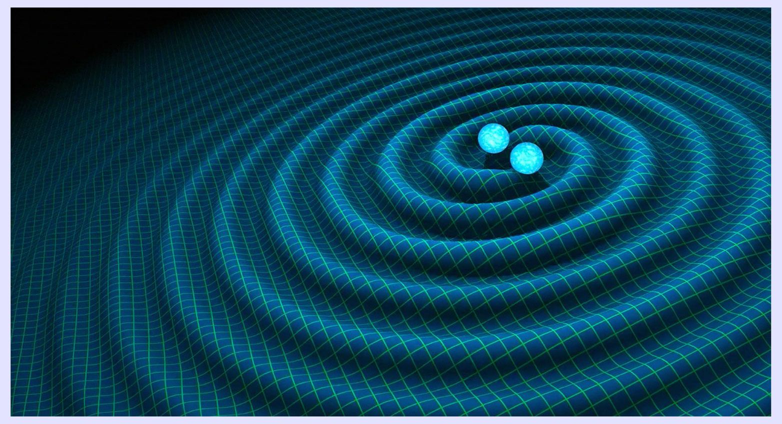
Observing the light bent by neutron stars can strengthen research of relativistic bodies, such as black holes. [5]


A neutron star system bending the trajectory of light.


A neutron star bends the trajectory of the light from a gas cloud.

GRAVITATIONAL WAVE DETECTION

Two massive orbiting bodies such as neutron stars emit significant gravitational waves, strong enough to be detected at observatories like LIGO. [6]


Digital representation of a binary neutron star system generating gravitational waves.

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