MOST OF THE ENERGY RELEASED IN TYPE II SUPERNOVA IS CARRIED AWAY BY NEUTRINOS. ONLY 0.1% OF THE RELEASED ENERGY IS CARRIED BY VISIBLE LIGHT.

NOTE: THE SPECTRUM OF TYPE II SUPERNOVA CONTAINS HYDROGEN SPECTRAL LINES FROM HYDROGEN IN TOP LAYERS OF THE RED GIANT.

WHAT IS LEFT AFTER TYPE II SUPERNOVA?

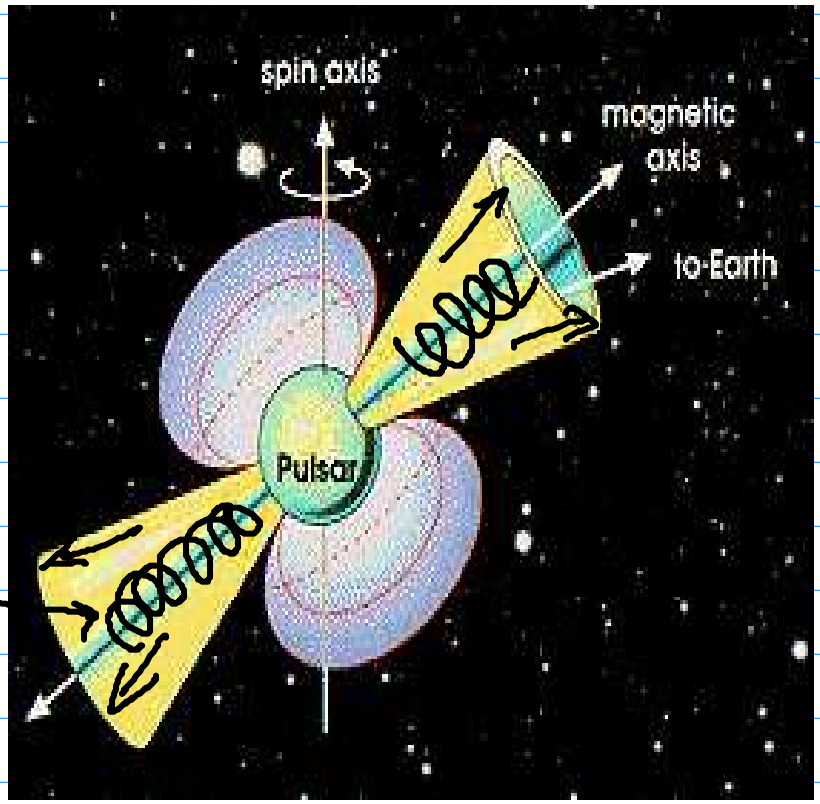
1) SUPERNOVA REMNANT: EXPANDING AND GLOWING GAS EJECTED BY THE EXPLOSION.

CRAB NEBULA RESULTING FROM SUPERNOVA IN 1054 AD OBSERVED AND DOCUMENTED BY CHINESE ASTRONOMERS.

2) NEUTRON STAR (IF THE MASS OF THE COLLAPSED CORE IS $< 3M_{\odot}$) OR A BLACK HOLE (IF THE MASS OF THE COLLAPSED CORE IS $> 3M_{\odot}$)

WHAT IS THE OBSERVATIONAL EVIDENCE FOR THE NEUTRON STARS?

OBSERVATION OF PULSARS, WHICH ARE FAST SPINNING NEUTRON STARS. LIGHTHOUSE MODEL FOR THE PULSAR:



SPIRALING ELECTRIC CHARGES

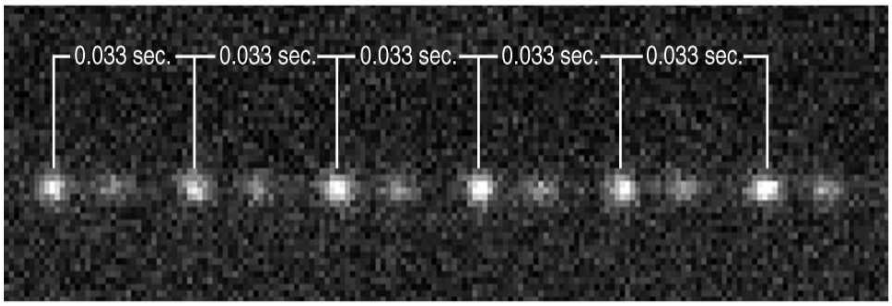
ELECTRIC CHARGES PULLED FROM THE SURFACE OF A NUTRON STAR (IT IS NOT ALL NEUTRONS)

SPIRAL AROUND MAGNETIC FIELD LINES AND AS A RESULT PRODUCE HIGHLY DIRECTIONAL ELECTROMAGNETIC RADIATION (RADIO, VISIBLE, X-RAYS, GAMMA RAYS). IF THE BEAM HAPPENS TO POINT TOWARD THE EARTH WE DETECT A PULSE OF RADIATION.

THEY WERE FIRST OBSERVED IN 1967 BY JOCELYN BELL

SHE DETECTED REGULAR RADIO PULSES (EVERY 1.33728 SECONDS) USING RADIO TELESCOPES.

BY NOW OVER 1500 PULSARS HAVE BEEN DISCOVERED WITH PERIODS FROM 0.001 SECOND TO 10 SECOND.



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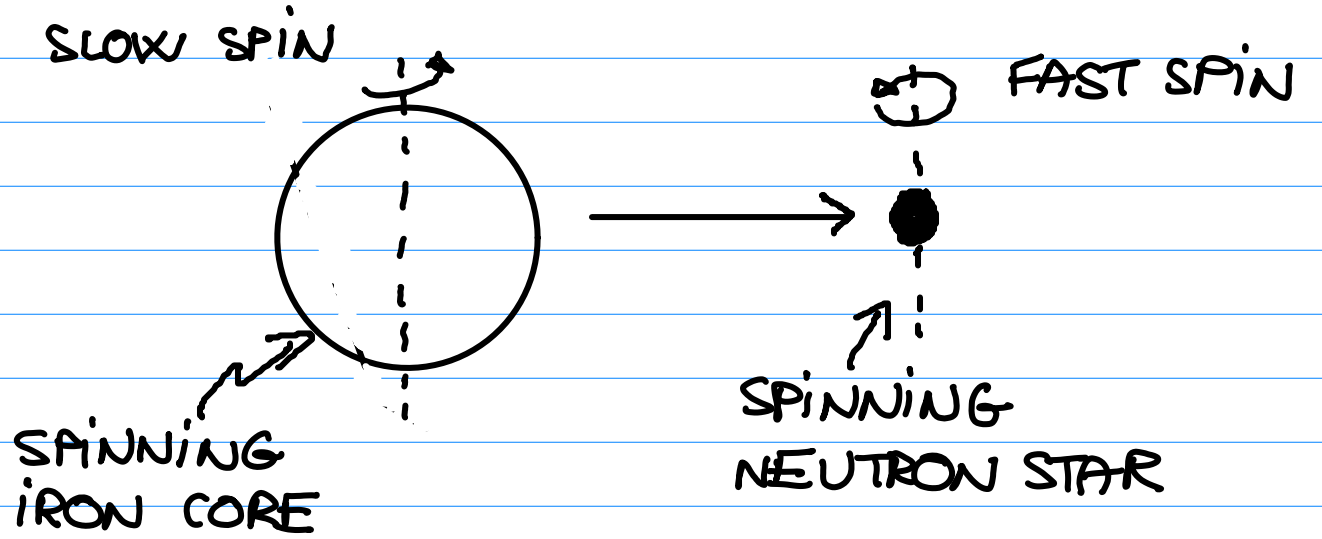
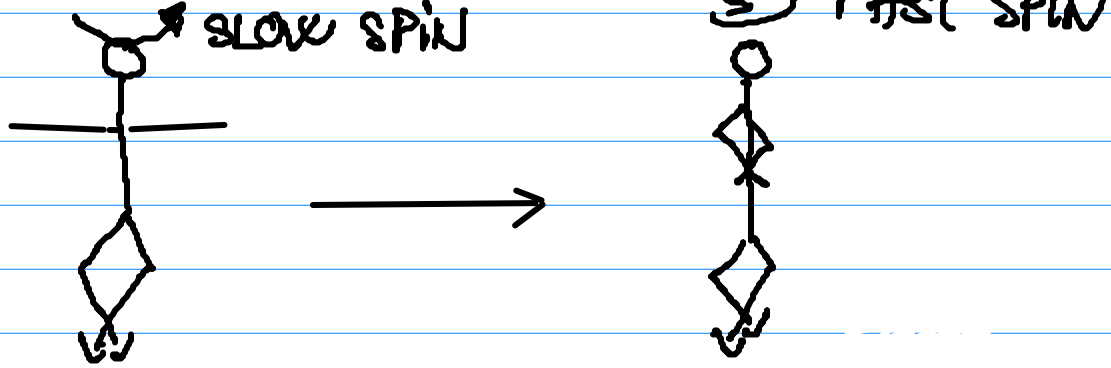
WHY IS THE SPIN OF A NEUTRON STAR FAST?

BECAUSE OF THE CONSERVATION OF ANGULAR MOMENTUM:



ANALOGY: A SPINNING SKATER



THE ANGULAR MOMENTUM $L = MRV$

MASS

ROTATIONAL SPEED

AVERAGE DISTANCE FROM ROTATIONAL AXIS

AS THE BODY OF A GIVEN MASS (M) CONTRACTS (R IS REDUCED) THE RATE OF SPIN (I.E. V) HAS TO INCREASE FOR THE ANGULAR MOMENTUM TO STAY UNCHANGED (I.E. CONSERVED).

THE SPIN RATE OF A NEUTRON STAR DECREASES OVER TIME AS IT LOSES THE ROTATIONAL ENERGY VIA RADIATION.