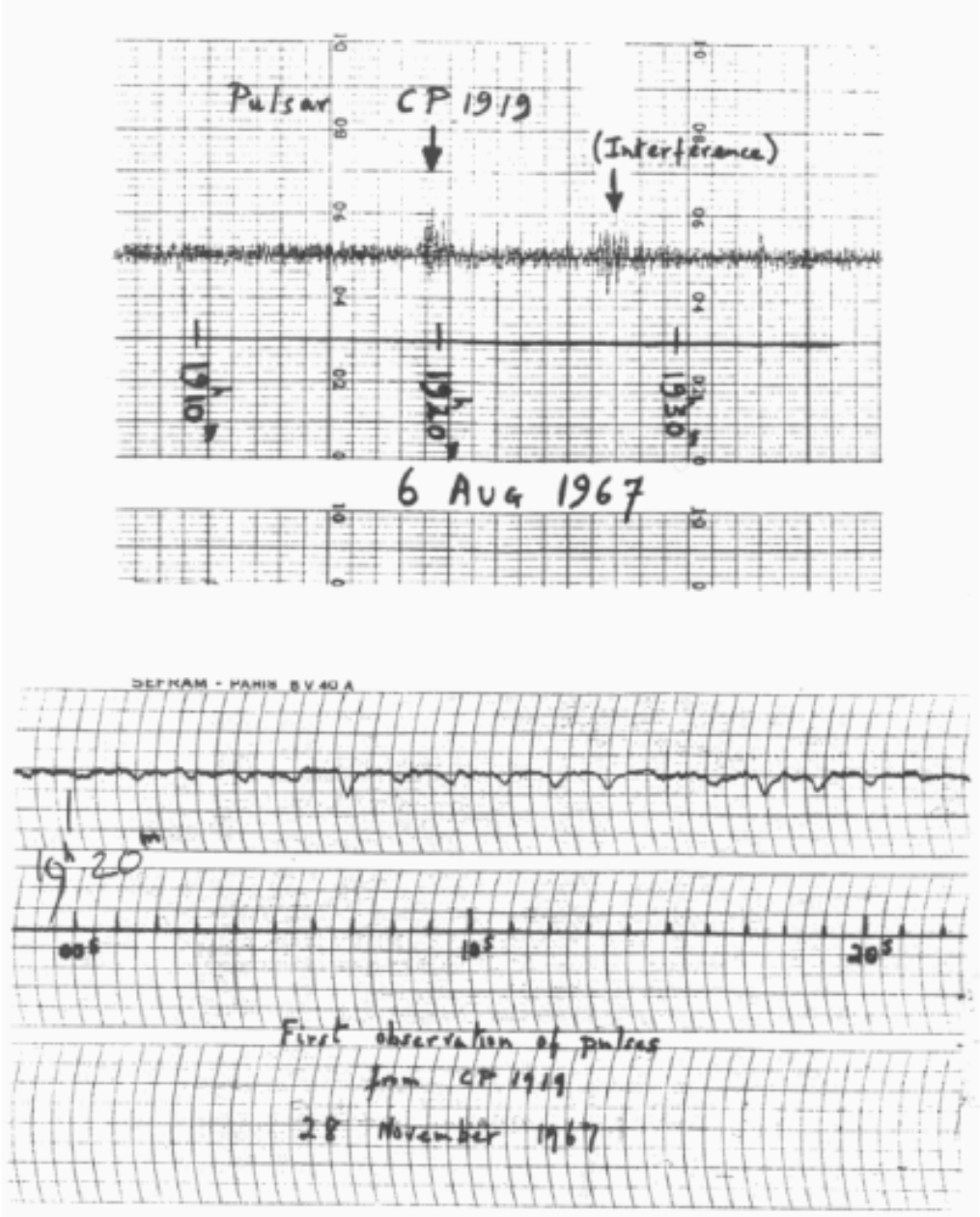
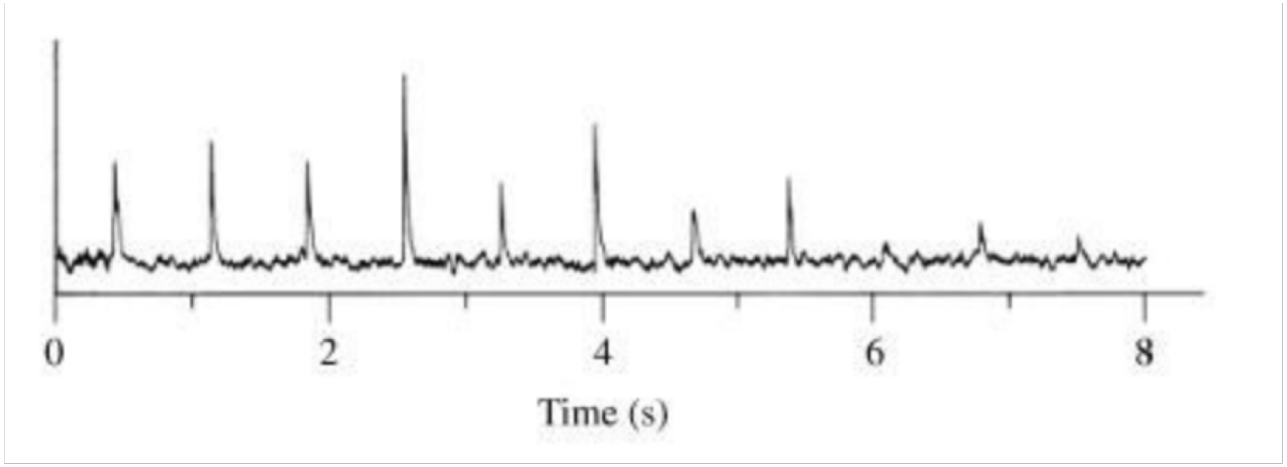
Pulsars

- Radio pulses discovered by Jocelyn Bell



Short Periods

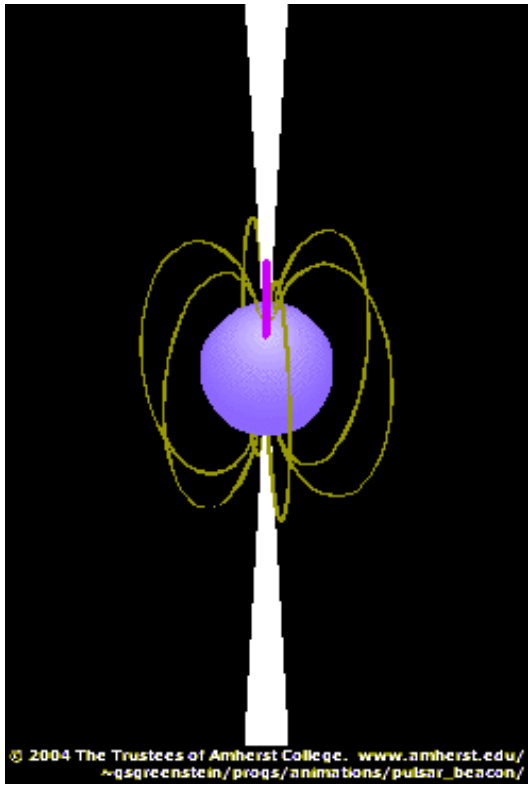
- Periods of pulses range from milliseconds to a few seconds
- Too fast for pulsations from any type of star and not alien signals

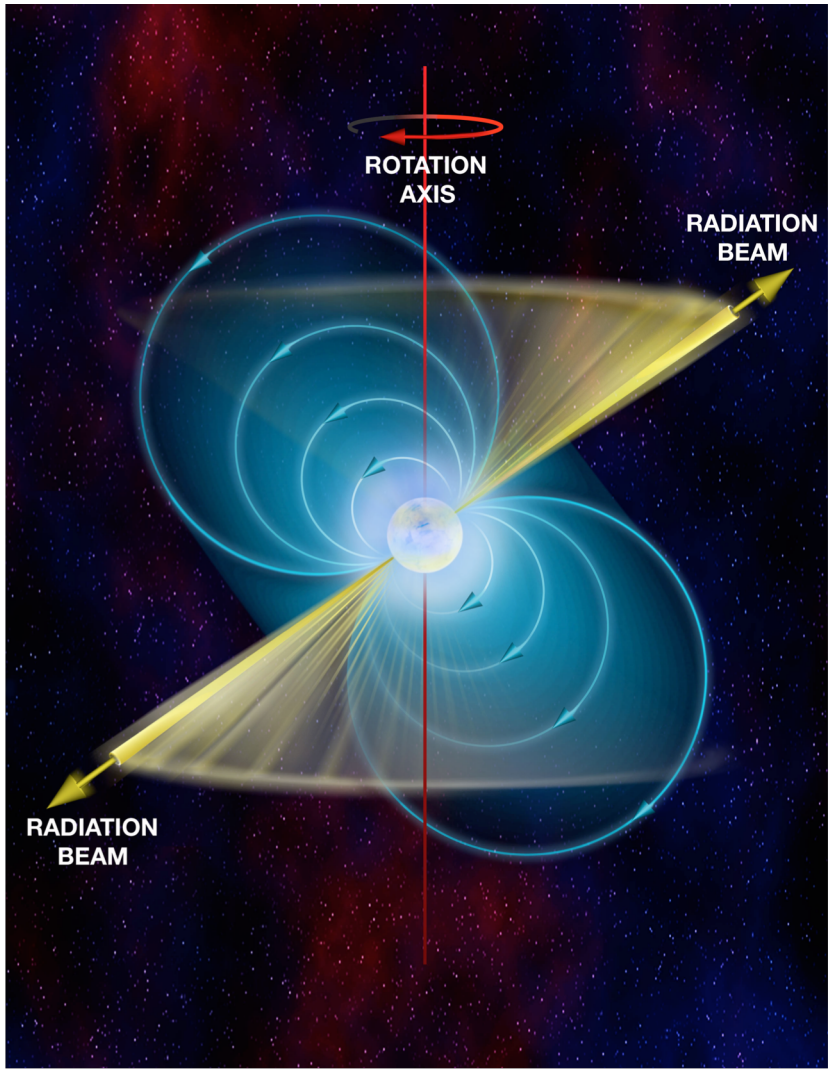


- (Sounds) (Optical)

Rotating Neutron Stars

- Fast rotating, highly magnetized neutron stars



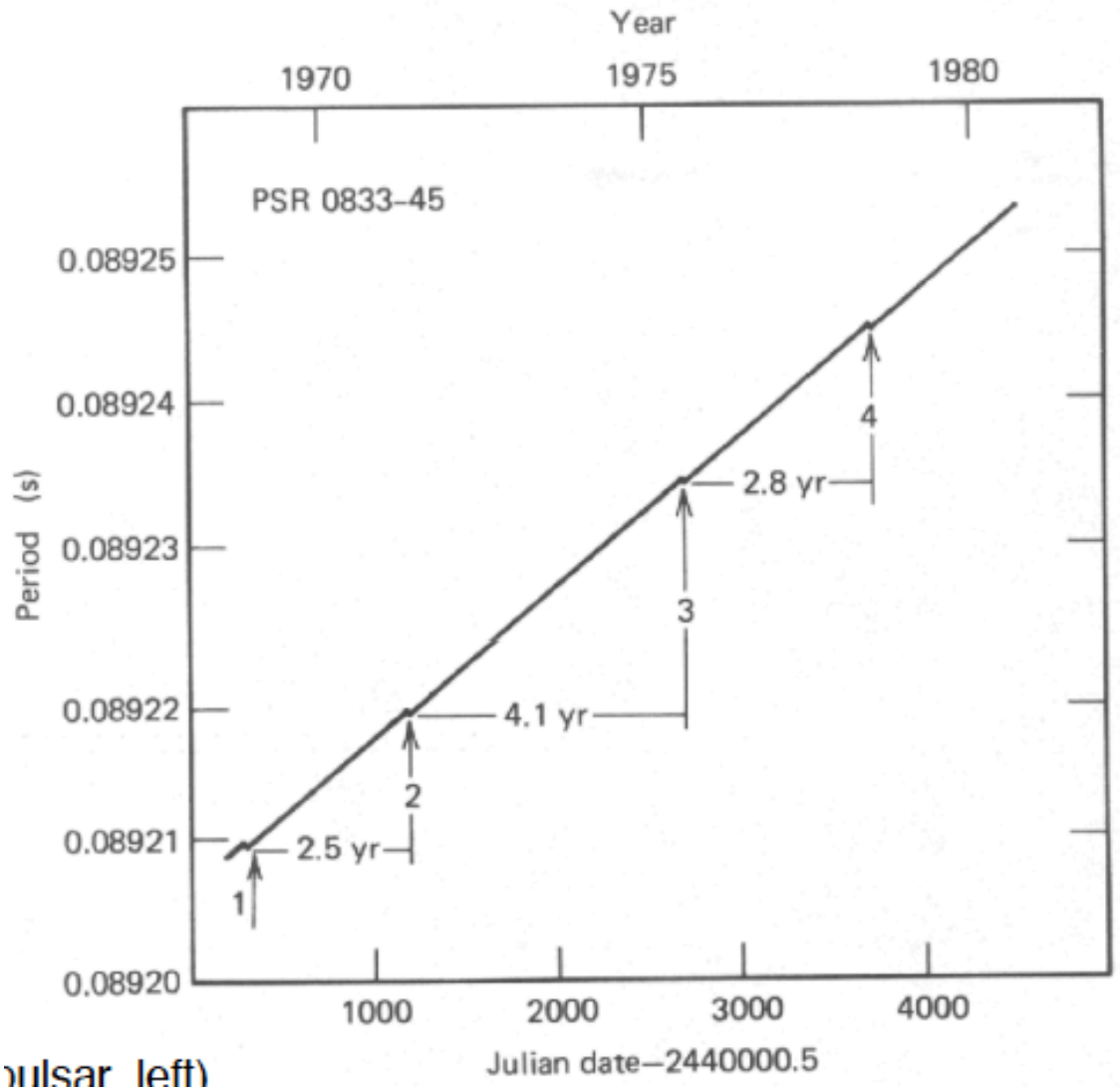


Pulsar Wind Nebulae

- The ejected beams sometimes power a nebula

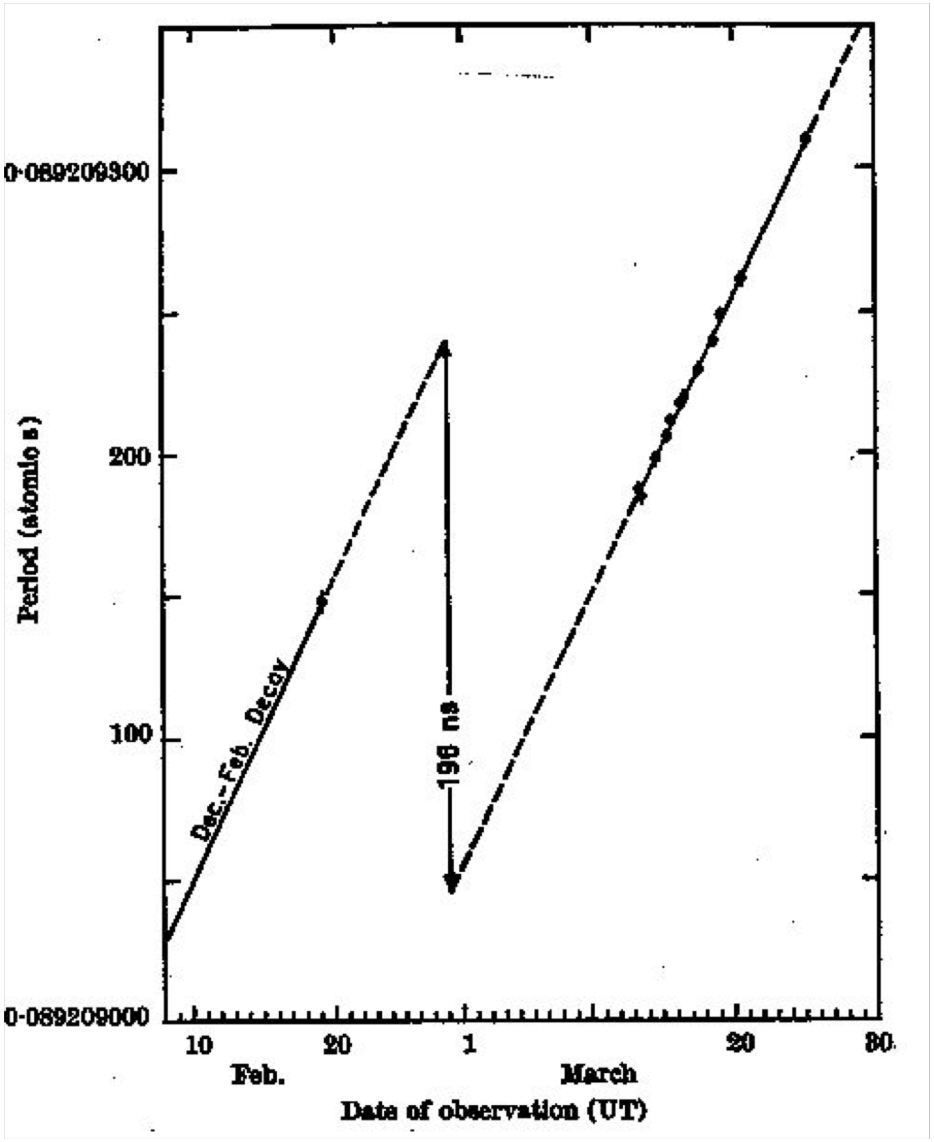
Pulsar Energy Source

- The rotation rate of pulsars is observed to slow down over time
- Due to drag of open magnetic field lines



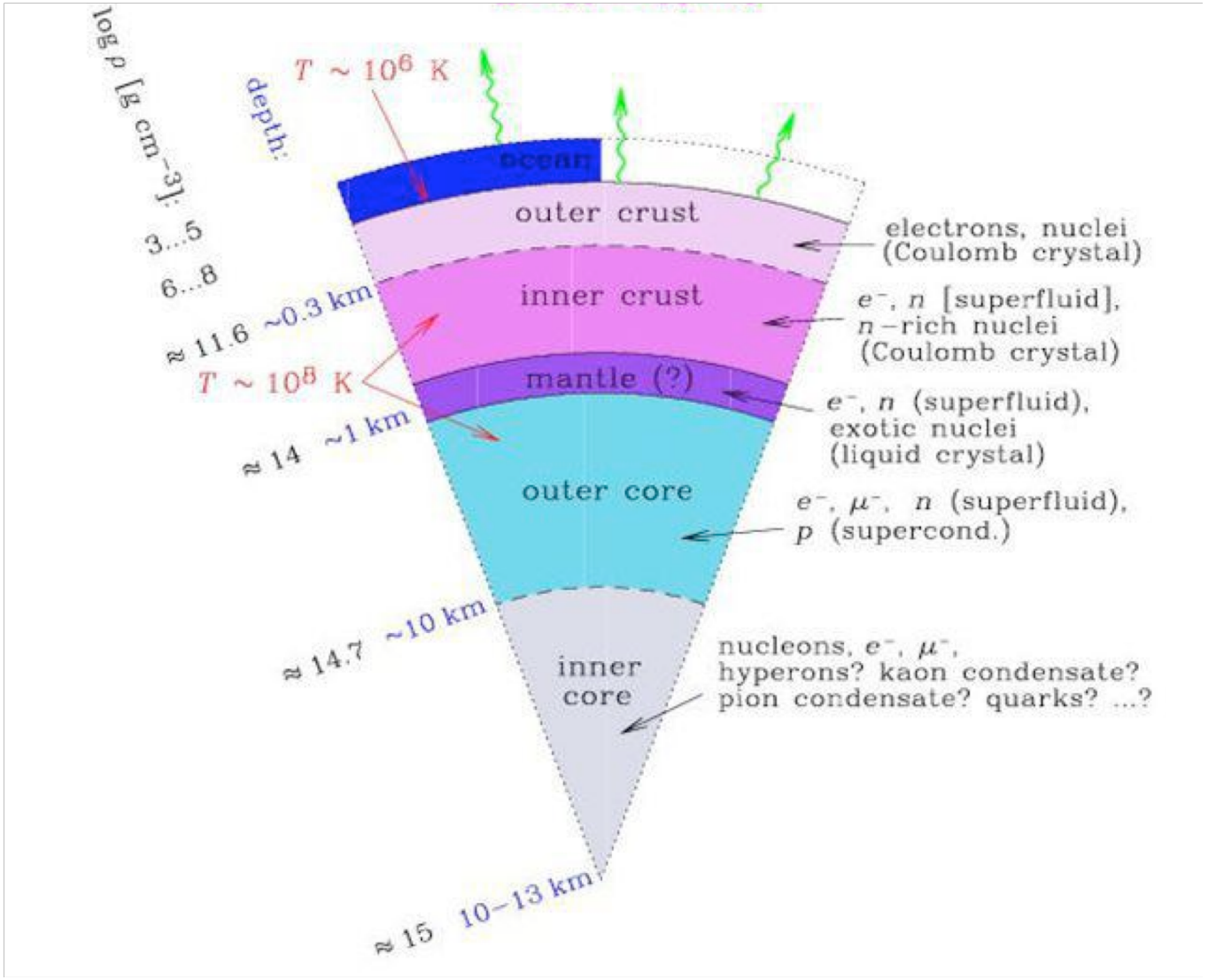
Glitches

- Occasionally the period changes abruptly
- Neutron star shrinks by a small amount
- Starquake



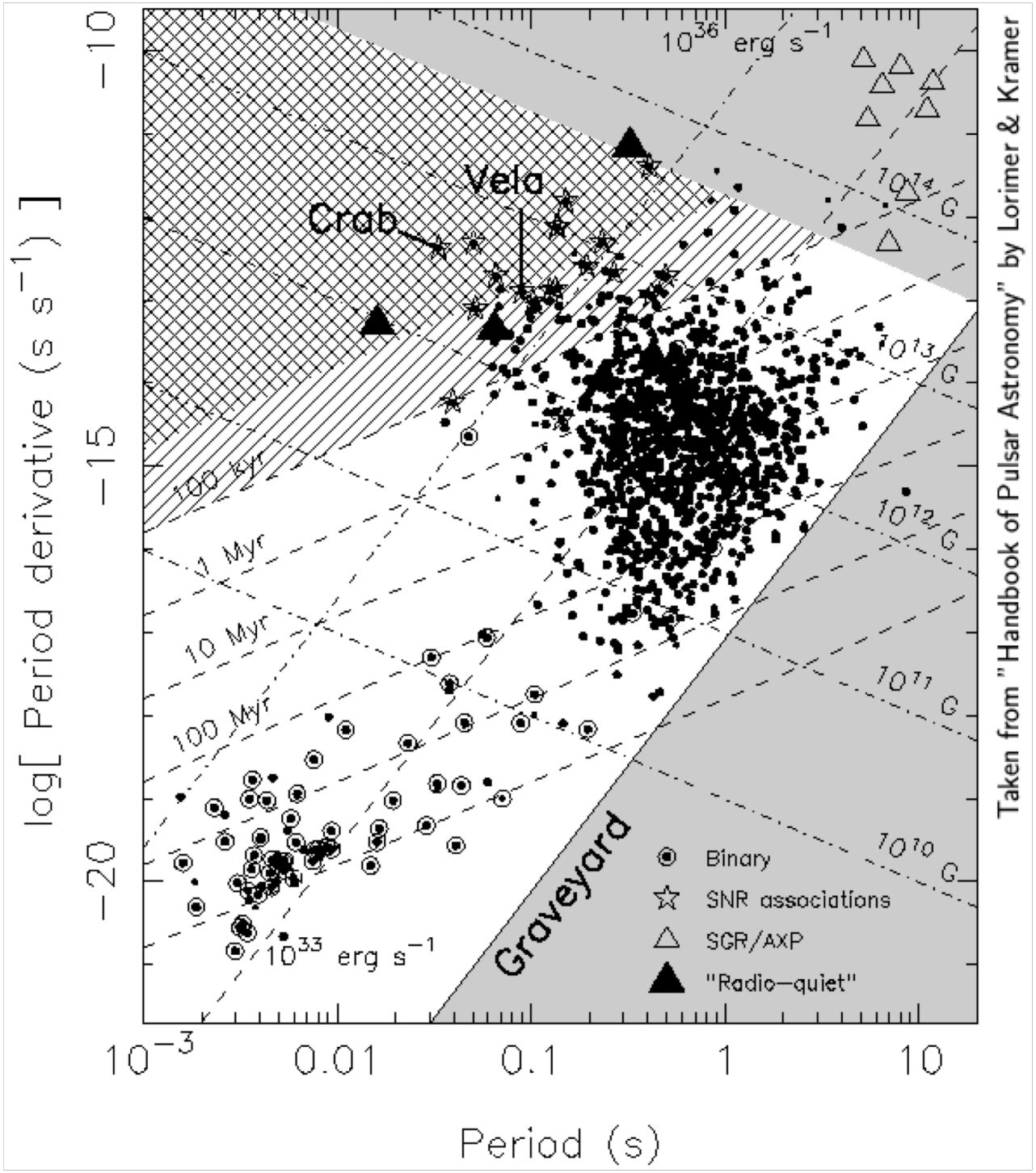
Internal Structure

- Solid crust overlays superfluid interior
- Crust adjusts as it cools and shrinks



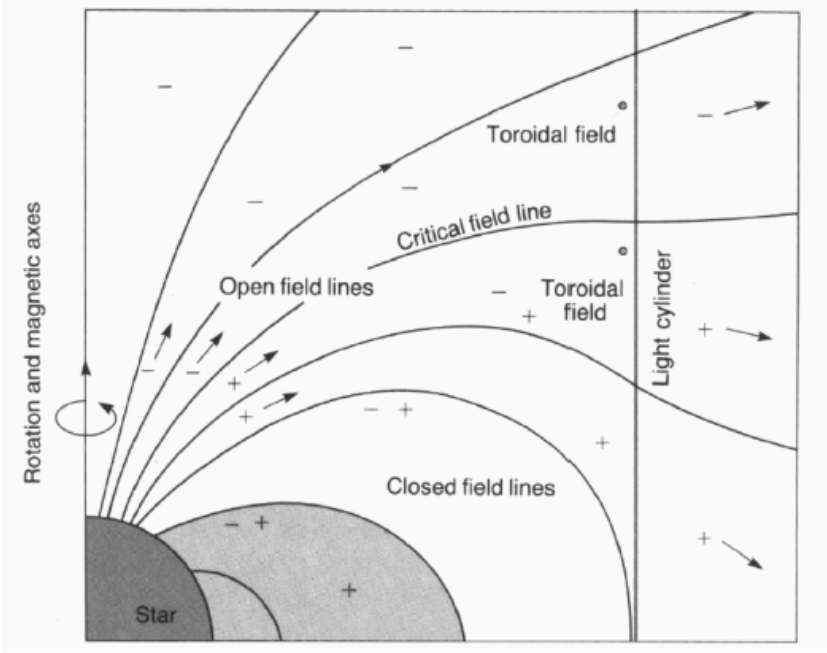
Ages

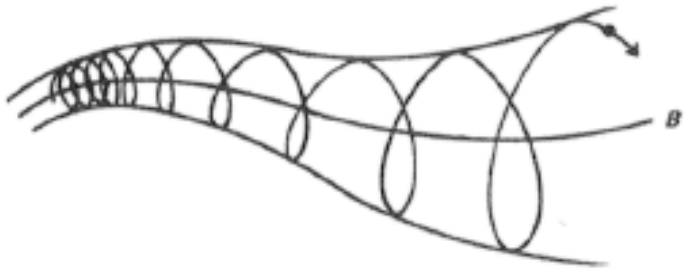
- Ratio of P to dP/dt gives indication of age
- Pulsars still associated with SNR are young



Emission Mechanism

- Fast rotating magnetic field induces large electric field (E=v x B)
- Pulls charged particles out of surface
- Electrons spiral along magnetic field lines giving curvature radiation



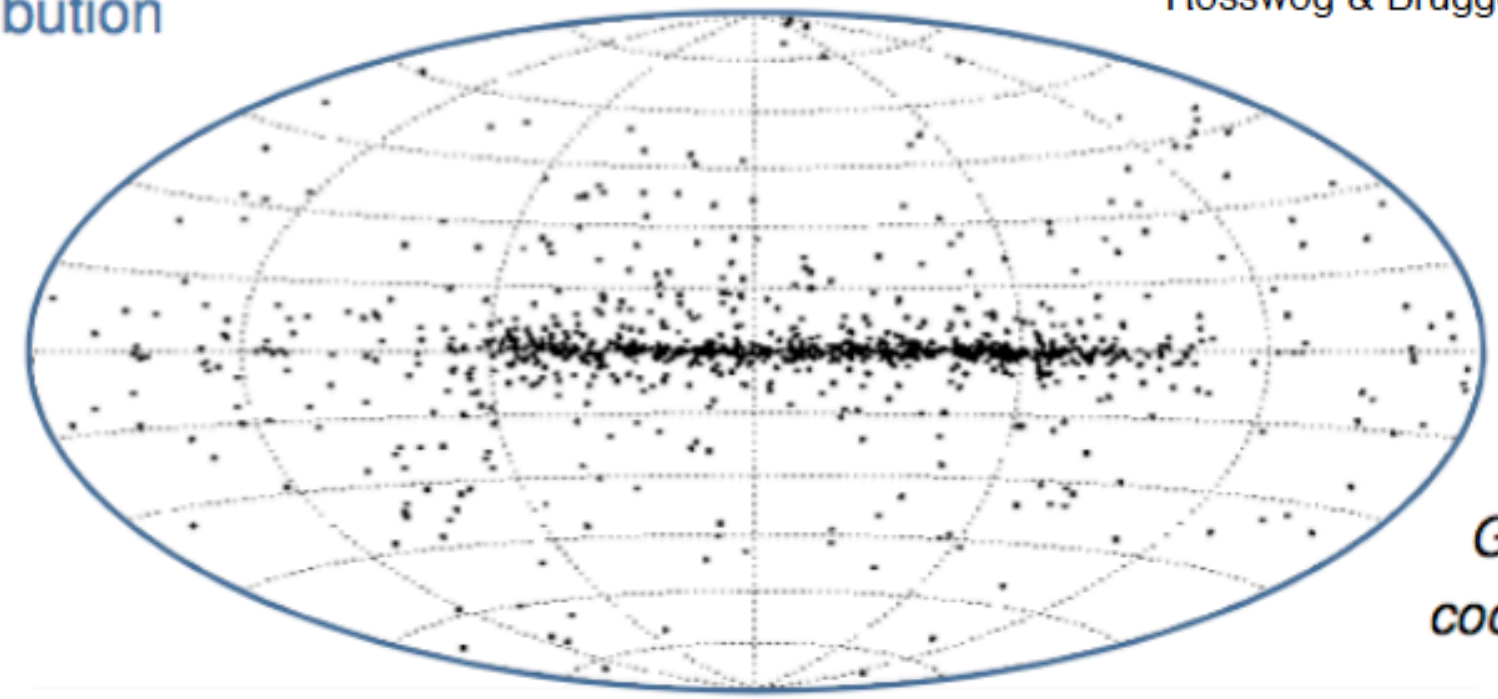


Distribution

- Mostly in galactic plane as originate from SN
- Can have high proper motions due to kick

Sky distribution

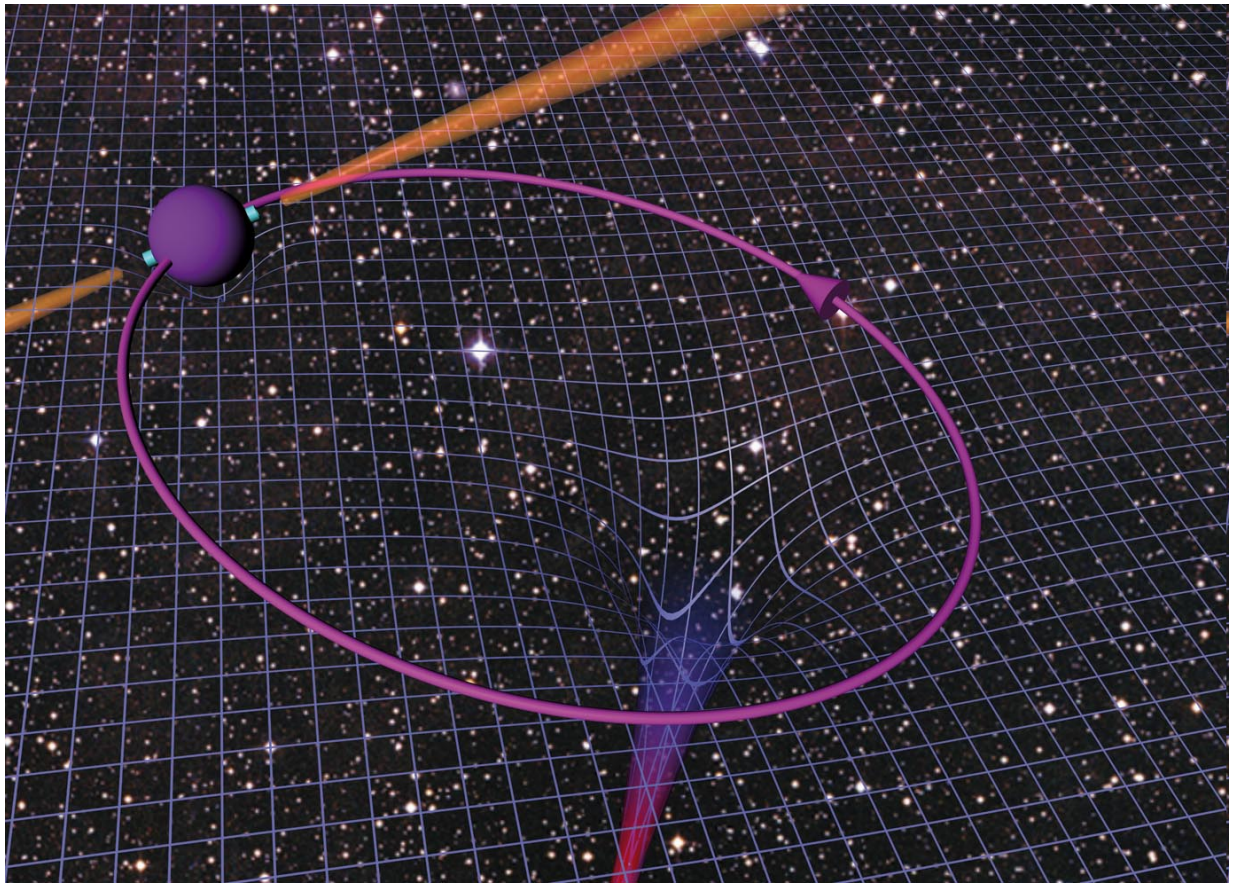
Rosswog & Bruggen Fig 5.2



Galactic coordinates

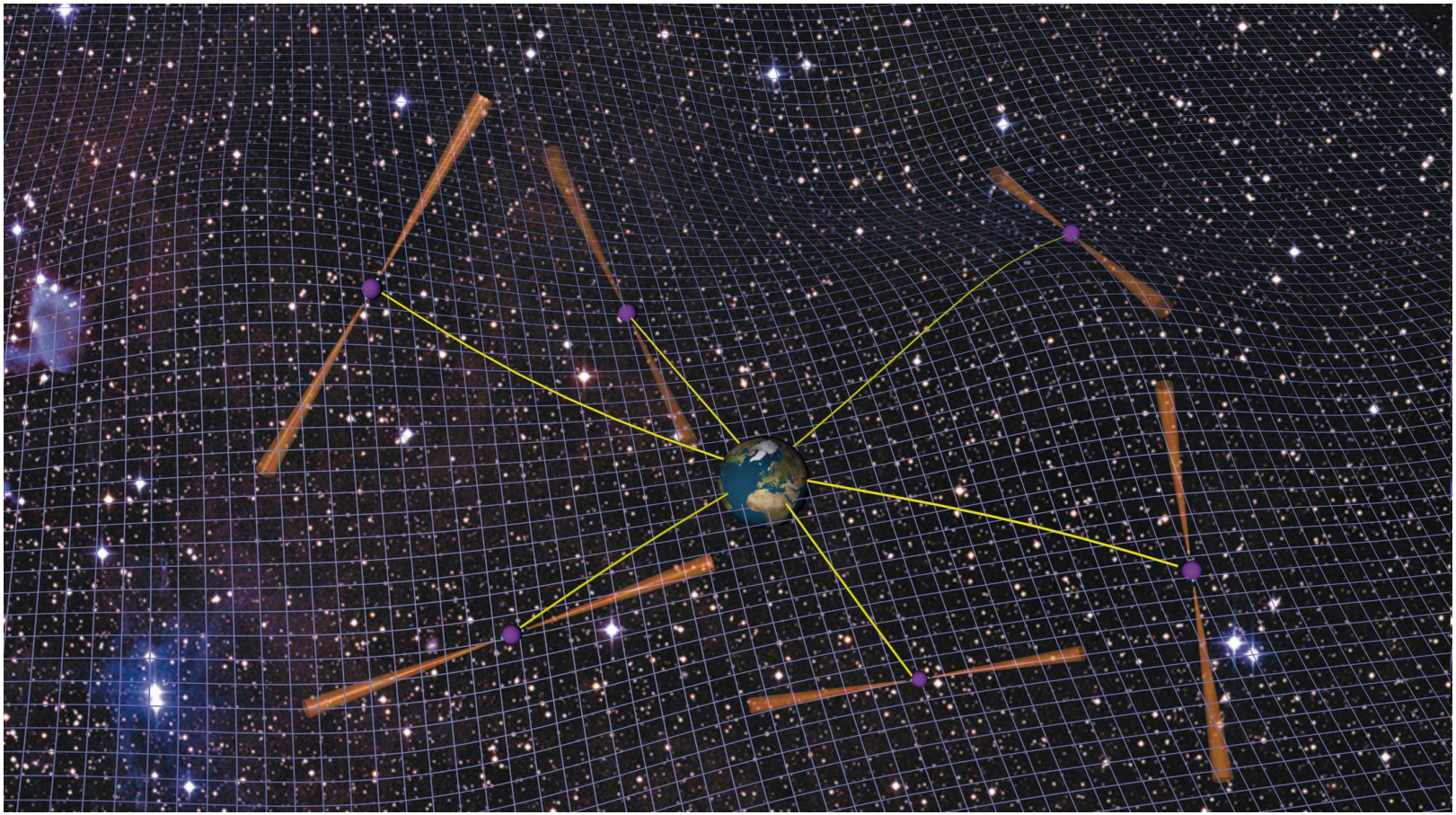
Testing Fundamental Physics

- A pulsar in orbit around a black hole would test Einstein's theory of general relativity



Gravitational Waves

- An array of clocks in space will detect gravity waves from colliding super-massive black holes



Summary

- Pulsars have a variety of uses:
  - Testing stellar evolution
  - Studying extreme forms of matter
  - Testing general relativity
  - Potential as a gravity wave detector