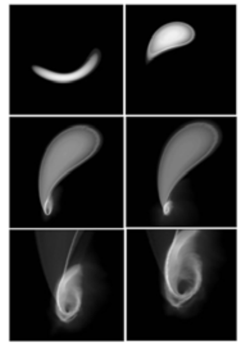
ASTR 1020: Stars & Galaxies
March 5, 2008

- Reading: Chapter 18, section 18.3; summary of key concepts.
- *MasteringAstronomy* Homework on Star Death is due March 10th.
- Exam 2 on Friday, March 14th(Chapters 15.3-19.2).
- **Meet Friday at Fiske Planetarium for "Dr. Einstein's Universe!**

Astronomy In the News
Varsha Shirhatti



Chandra Video

The Stellar Graveyard

Low mass stars → white dwarfs
gravity vs. electron degeneracy pressure

High mass stars → neutron stars
Gravity vs. neutron degeneracy pressure

Even more massive cores → black holes
Gravity wins…..

White Dwarfs

- For solar-mass star, a hot core of carbon (can also be oxygen for higher mass stars)

Size ~ Earth !!
Density – 1 cm^3 weighs about 5 tons

Cool from white-blue through red to black

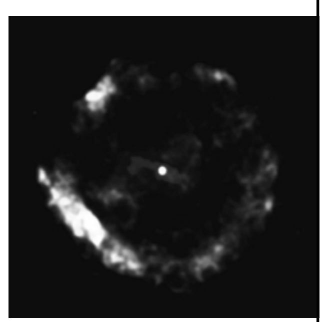
Today: Neutron Stars

- Gravity vs. Neutron degeneracy pressure
- Size ~ 10 km !!

Crushing gravity at its surface

Neutron star over NYC

- Supernova remnant (386 AD) and pulsar, seen in X-ray light

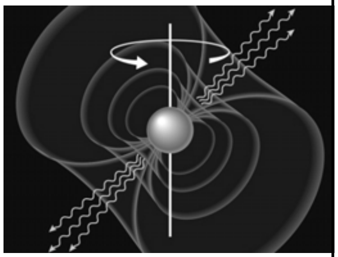


Pulsars

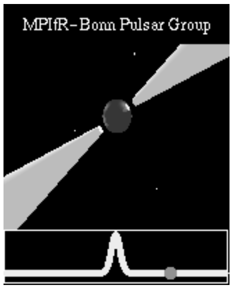
- Collapse to a neutron stars increases both rotation and magnetic field
- Newly collapsed neutron stars rotate 100s to 1000s of times per second

- Magnetic fields focus energy/radiation along magnetic poles

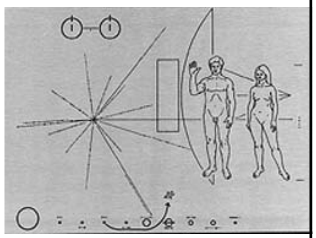
New form of light = synchrotron radiation



- When the “beam” sweeps across the Earth, we see a pulsar



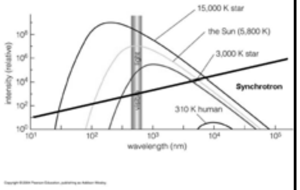
- Earth lies at the unique intersection of many pulsar beams– use these as galactic pointers to our location



Pioneer 10 spacecraft panel- now past Pluto

Synchrotron Radiation

- Fast electrons in strong magnetic fields → neutron stars, black holes
- Different shape from thermal radiation: strongest emission in radio



Clicker Question

- The coolest objects in the galaxy are at about 29 K, and the hottest stars are at 29,000 K. At what wavelengths do synchrotron radiation dominate?

  Wien’s law: wavelength = 2,900,000 nm / T

a) less than 0.1 mm, more than 1000 nm
b) less than 0.1 mm, more than 100 nm
c) less than 1 mm, more than 1000 nm

1 mm = 0.001 m = 1,000,000 nm

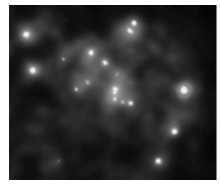
a) Cold Wavelength = 2,900,000/29
=100,000 nm
= 0.1 mm
This is in the far IR, near the edge of radio.

b) Hot Wavelength = 2,900,000 / 29,000
= 100 nm
This is in ultraviolet light.

c) So, this is answer – less than 1mm, more than 1000 nm
This is the radio part of the spectrum.

Not matched scales!

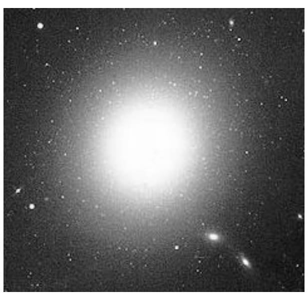
Normal stars

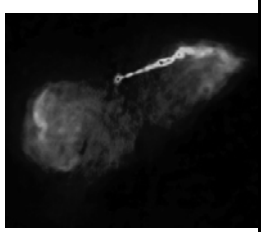


Neutron stars, black holes

- Really stands out in radio and X-ray where there is little thermal radiation
- Visible light versus X-rays show stars versus “collapsed objects”

Visible light vs. Radio Thermal versus Synchrotron



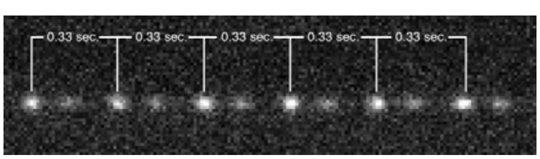


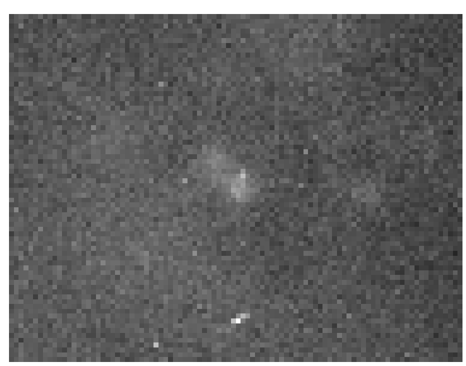
Observing Pulsars

- Jocelyn Bell: Cambridge graduate student in 1967 discovered pulsars by accident from an early radio telescope
- LGM’s?

Pulsar “Lighthouses” don’t actually pulse

- Must be very compact object to spin so fast
- Spin slows down gradually (thousands of years)



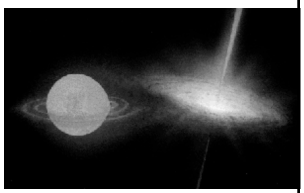


Neutron Stars in Binary Systems

- Mass transfer:
- Gravitational potential energy
  → X-ray radiation emission

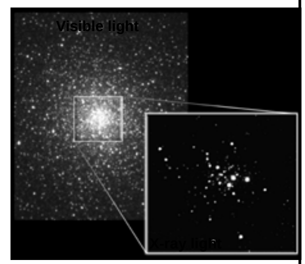
X-Ray Binary system,
X-ray bursters

Matter falling through the spinning disk can spin UP the pulsar!



Visible versus X-ray

- Thermal light from stars → visible and IR
- Synchrotron light from neutron stars → X-ray and radio



When the mass is too great….

- For even neutron degeneracy to hold up, supernova core collapses to an infinitely small point
- → Black Hole:
  Next class at Fiske Planetarium on "Dr. Einstein's Universe".