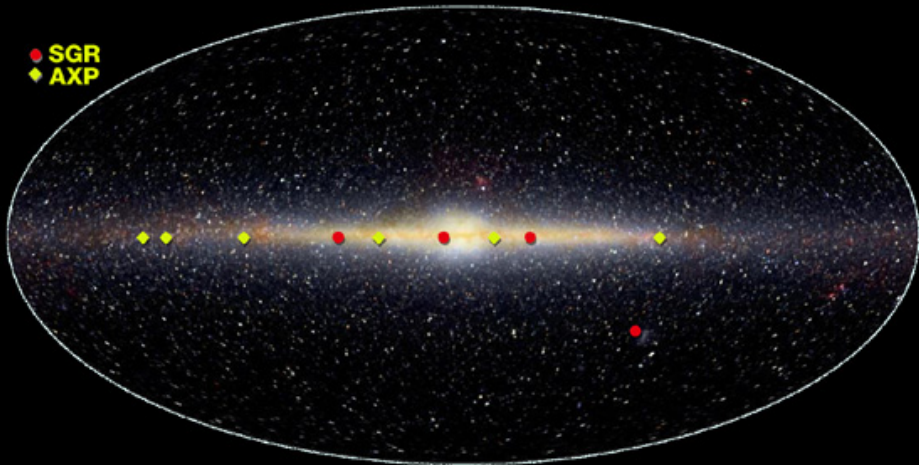


Magnetars and Soft Gamma-Ray Repeaters

- ▶ Soft gamma repeaters (SGRs) emit bright, repeating flashes of soft (low-energy) gamma rays.
- ▶ First discovered in 1979 seen on January 7 from a source in Sagittarius. Soon followed by the most intense blast of gamma rays every observed from outside the solar system, on March 5, 1979. 9 days later, another SGR became active with 3 bursts within 3 days. Since then, only 2 new SGRs have been observed.
- ▶ By 1987, realized that SGRs were different from GRBs: they were soft (actually hard X-rays) and they repeated.
- ▶ Normal SGR bursts have $E = L_{\odot} \times 1 \text{ yr}$. Brightest bursts 1000 times brighter. Timescales are 1 s. 4 of the SGRs are within our Galaxy, and 1 is just outside.
- ▶ It is estimated that millions of SGRs exist in our Galaxy, but they last only 10,000 years or so.
- ▶ SGR bursts distinct from other repeating bursting sources: Type I and Type II X-ray bursts, black hole X-ray transients, cataclysmic variables, and novae, which originate from compact accreting stars. These other sources are 1000-10,000 times fainter, but last longer.

Known magnetar candidates

● SGR
◆ AXP



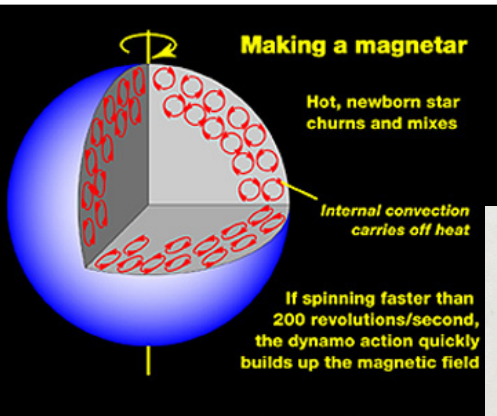
Why Highly Magnetized Neutron Stars?

- ▶ Spin down of star to about 8 s period in the 10,000 yr age of SNR (magnetic dissipation)
- ▶ Provide enough energy for flares
- ▶ Account for short, 0.2 s, duration of the hard spike (timescale of large-scale magnetic field readjustment)
- ▶ Provide enough energy for steady X-ray glow of SGRs
- ▶ Make a hot particle gas (fireball) to explain soft tail and intensity of bursts
- ▶ After fireball disperses, makes a residue held down by magnetic forces
- ▶ Explains periodicity in light curve

Trapped Fireballs

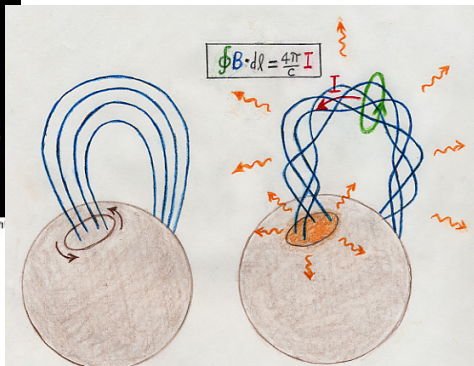


Model for SGRs

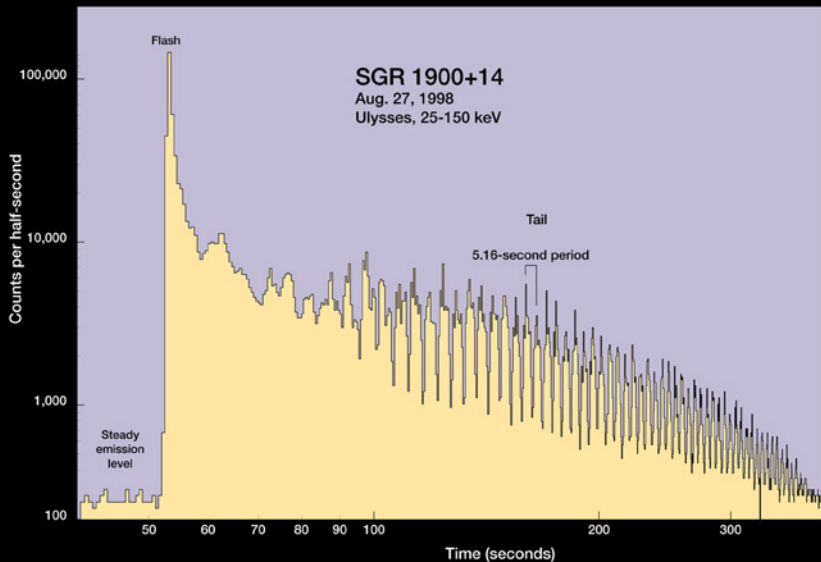


Dave Dooling, NASA Marshall Space Flight Cen

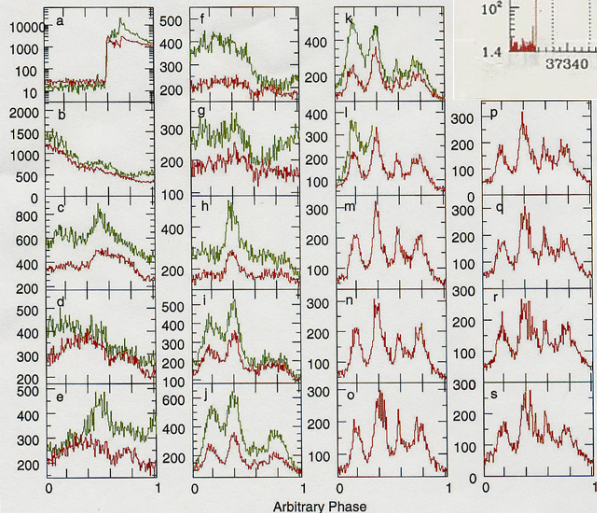
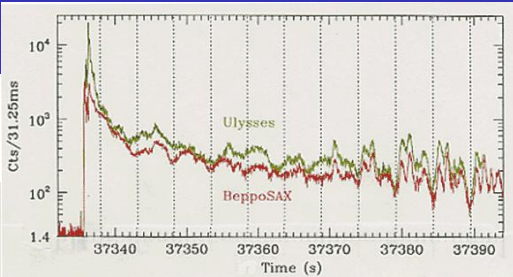
Duncan & Thompson



SGR Light Curve



SGR Light Curve Detail



Some of the 21 Known Magnetars

- ▶ SGR 1806-20, $d = 50,000$ lt-yr (Sagittarius), $b = 10^{15}$ G. 2004 burst was brightest event outside solar system sighted on Earth. Energy released was 10^{46} erg; from a distance of 10 lt-yr would have destroyed the ozone layer. Ionosphere expanded
- ▶ SGR 1900+14, $d = 20,000$ lt-yr (Aquila). In 1998, forced NEAR Shoemaker to shut down and saturated detectors BeppoSAX, WIND and RXTE. A ring seen was probably formed in 1998 burst.
- ▶ SGR 0501+4516, $d = 15,000$ lt-yr
 - ▶ 1E 1048.1-5937, $d = 9000$ lt-yr (Carina) is the nearest known magnetar (AXP)
 - ▶ SWIFT J195509+261046, formerly GRB 070610
 - ▶ CXO J164710.2-455216 (AXP) in Westerlund 1 (galactic cluster)

