Gamma Ray Bursts: The Mysteries Surrounding Nature’s Most Powerful Explosions

Discovery of GRBs

- US launched Vela to find nuclear tests by Russia
- Found occasional bursts of gamma rays, not from nuclear tests (1967)
- What makes these GRBs?
Initial Observations

- Not from Earth (time-delay)
- Last 0.1 sec – few minutes
  - Must occur in a small volume
- Must be powerful to produce intense gamma rays

A Closer Look

- GRB in Large Magellanic Cloud (1979)
- $10^{44}$ ergs!
  - As much as Sun emits in 1000 yr
- What is the source of this powerful burst?
Observing GRBs

- Short and unpredictable
- Gamma rays pass through mirrors
- Gamma rays won’t pass through Earth’s atmosphere
- Solution: Sophisticated Satellites

Location of GRBs

- Compton Gamma Ray Observatory (1991)
- Measured positions to 1°
- GRBs not exclusively on Galactic plane
- GRBs not reoccurring from same source
Other Observations

- Visual counterpart in distant galaxy (1997)
- Confirmed by redshift measurements through HETE 2
- Absorption features in spectra – magnetic fields?
- Polarized gamma rays – magnetic fields?

Theory #1 - Merging Neutron Stars

- 2 neutron stars orbit closely
- Lose energy through gravity waves
- Merge, produce black hole
- GRB!
Support for Theory #1

- Energy loss rate of orbiting neutron stars matches predictions
- Neutron stars have strong magnetic fields
- Mechanism for intense gamma ray production?

Theory #2 – Massive Star Collapse

- Type Ic Supernova
- Massive star dies, forming black hole
- Infalling matter would form superheated disk around equator
- Magnetic fields would push radiation out of poles, produces
Support for Theory #2

- Mechanism for gamma ray production
- Magnetic fields play role
- GRBs more common, less intense

Future Research

- Important (clues about 1st generation stars)
- Three new satellites:
  - ROTSE = find visible afterglows
  - HETE = fast, precise locations
  - Swift = precise locations, redshifts
Questions?