

Modeling High Energy Radiation from X-ray Binaries

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Outline

Introduction

- High Energy Radiation
- Atmosphere Window

X-ray Binaries

- Low-mass XRBs
- High-mass XRBs

Objectives of the Study

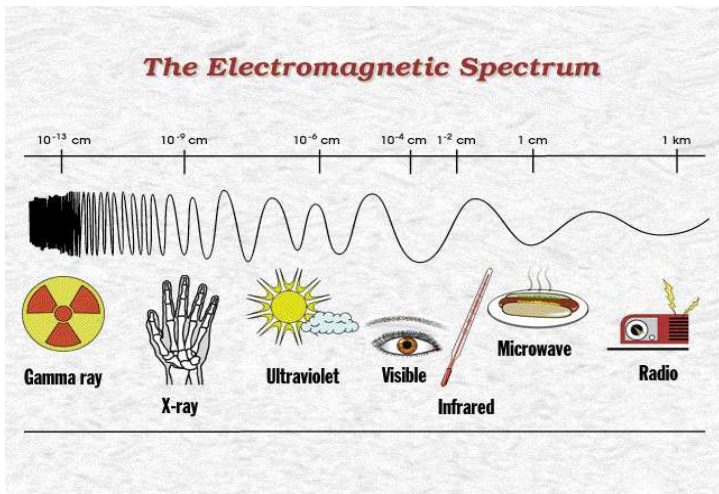
- Aim of the Study
- Specific Objectives

Methodology

- Data Reduction and Analysis
- Modeling Radiation Processes

Introduction

- ▶ Electromagnetic radiations range from radio waves, through visible light, to gamma rays, that is, from low frequencies (long λ s) to high frequencies (short λ s); Recall, $c = f\lambda$.



Introduction Cont...

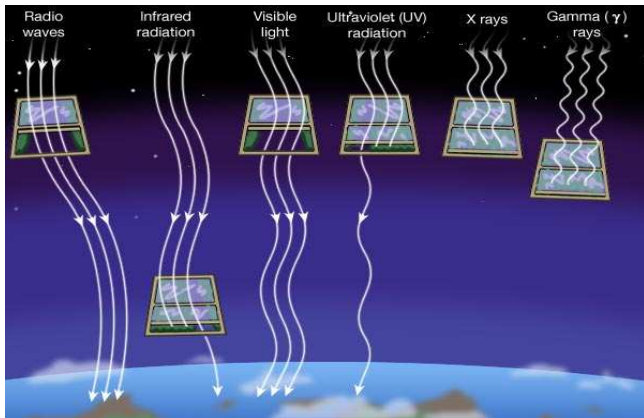
- ▶ High energy radiation mainly deals with X-rays (0.1 - 100 keV) and γ -rays (> 100 keV).
- ▶ High energy radiation is produced by objects at high temperatures and/or relativistic particles ($v \sim c$).
- ▶ It usually requires compact objects, e.g. white dwarfs (WDs), neutron stars (NS), black holes (BHs), with deep gravitational potential;

$$V_{\text{esc}} = \sqrt{\frac{2GM}{R}} \text{ approaching } c, \text{ with } R \text{ not much greater than Schwarzschild radius: } 2GM/c^2$$

- ▶ WD: $R \sim 10,000$ km, $V_{\text{esc}} \sim 0.02c$, $\rho \sim 10^{14}$ g/cc.
- ▶ NS: $R \sim 15$ km, $V_{\text{esc}} \sim 0.32c$, $\rho \sim 10^{14}$ g/cc.
- ▶ BH: Schwarzschild radius = $2.95 \text{ km } M/M_{\odot}$.

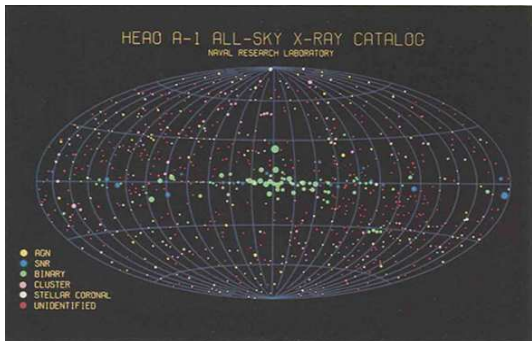
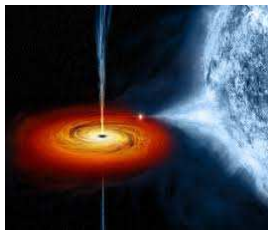
Observations of High Energy Radiation

- ▶ Note that the Earth's atmosphere is opaque to high energy radiation. High energy radiation requires space-based observatories, e.g. satellites.



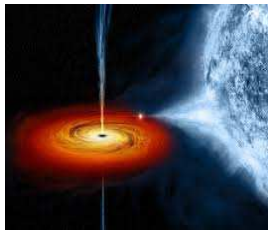
X-ray Binaries (XRBs)

- ▶ XRBs are binary stars which emit large amounts of X-rays.
- ▶ XRBs are the brightest X-ray sources in our galaxy, and were among the first X-ray sources to be discovered.



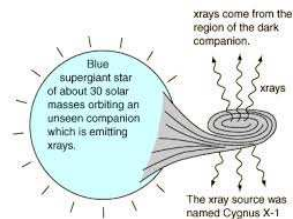
X-ray Binaries (XRBs)

- ▶ Two stars in orbit; one of them a normal star, and the other a collapsed/compact star, usually a neutron star or black hole.
- ▶ The normal/donor star transfers mass to the compact star.
- ▶ There are two main types of XRBs, depending on the mass of the normal (companion) star.
- ▶ A low-mass X-ray binary (LMXB) is one where the normal/donor star is less massive than the compact object, and can be on the main sequence, a degenerate dwarf (white dwarf), or an evolved star (red giant).
- ▶ A typical LMXB emits almost all of its radiation in X-rays, making LMXBs among the brightest objects in the X-ray sky.



X-ray Binaries (XRBs)

- ▶ A high-mass X-ray binary (HMXB) is one in which the normal stellar component is a massive star: usually an O or B star, a Be star, or a blue supergiant. E.g. Cyg X-1.



- ▶ In HMXBs, the massive star dominates the emission of optical light, while the compact object is the dominant -ray source.
- ▶ An intermediate-mass X-ray binary (IMXB) is one in which the normal component is an intermediate-mass star.
- ▶ Generally, X-rays are produced by matter falling from the normal star to the compact star.
- ▶ The infalling matter releases gravitational potential energy in the form of X-rays.

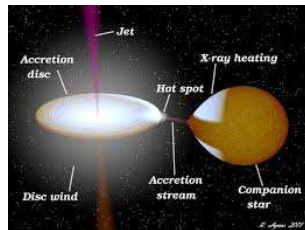
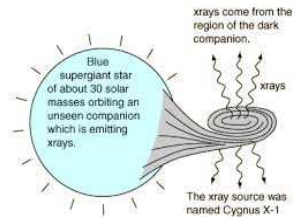
Objectives of the Study

General objective

- ▶ To model high energy radiation from X-ray binaries.

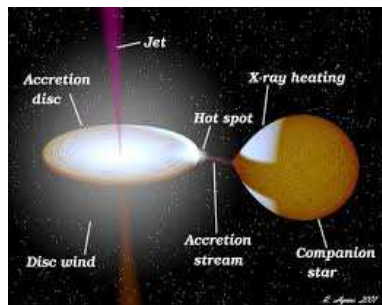
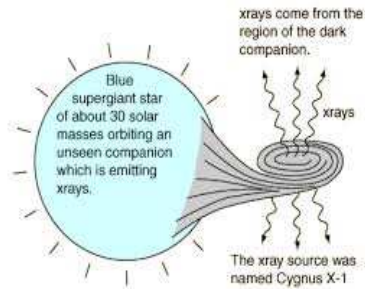
Specific objectives

- ▶ To determine the nature of X-ray light curves from X-ray binaries.
- ▶ To determine the nature of γ -ray light curves from X-ray binaries.
- ▶ To determine the nature of X-ray spectra from X-ray binaries.
- ▶ To determine the nature of γ -ray spectra from X-ray binaries.



Objectives of Cont...

- ▶ To determine the high energy radiation processes in X-ray binaries.



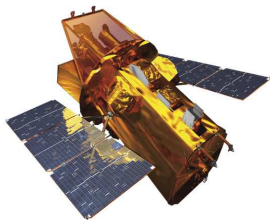
Methodology

Source Identification

- ▶ Catalog & literature sources
- ▶ HMXBs& LMXBs

Data Aquisition

- ▶ Data will be obtained from High Energy Astrophysics Science Archive Research Center (HEASARC).
- ▶ Alternatives for X-ray data.



SWIFT



CHANDRA

Methodology

Source Identification

- ▶ Catalog & literature sources
- ▶ HMXBs& LMXBs

Data Aquisition

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- ▶ Alternatives for X-ray data.

XMM-NEWTON



RXTE



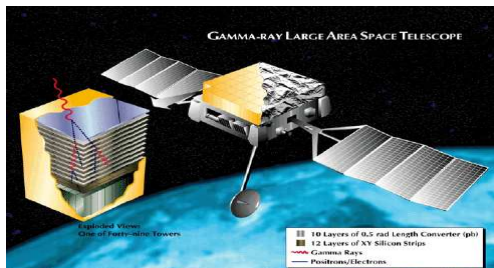
Methodology

Source Identification

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Data Acquisition

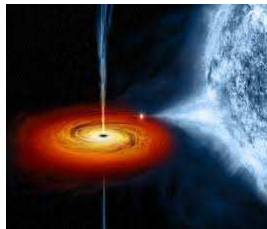
- ▶ Data will be obtained from High Energy Astrophysics Science Archive Research Center (HEASARC).
- ▶ Gamma ray data observed by FERMI.



Methodology

Data Reduction and Analysis

- ▶ To use appropriate Softwares as recommended, e.g.
- ▶ HEASOFT; SWIFT.
- ▶ CIAO; CHANDRA
- ▶ XSPEC; Spectral fitting



Modeling

- ▶ To theoretically model the radiation processes.

