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Paper Session II-A - Gamma Ray Observatory: Viewing the Violent Universe

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THE GAMMA RAY OBSERVATORY: VIEWING THE VIOLENT UNIVERSE

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ABSTRACT

The Gamma Ray Observatory (GRO), the second in NASA's series of Great Observatories, is the next major thrust in astrophysics. The 35,000 pound satellite is scheduled for a Shuttle launch in April 1991. By observing the sky in gamma rays, which are the most energetic form of electromagnetic radiation, GRO will be exploring some of the most violent phenomena in the universe. The four instruments on the GRO will allow a comprehensive look at gamma ray emission from such sites as supernova remnants, pulsars, the Galactic Center, and quasars. GRO will also investigate intriguing astrophysical processes such as the origin of gamma-ray bursts, the balance of cosmic rays with gas and magnetic field in the Galaxy, and matter-antimatter annihilation. Plans for the mission include an all-sky survey during the first year, followed by selected observations in the second and succeeding years.

INTRODUCTION

In seeking to learn about the Universe on a large scale, observers must derive their knowledge from the many types of radiation which reach the near-Earth environment. Because gamma rays are the most energetic form of electromagnetic radiation, they bring information about high-energy, often violent, processes in astrophysical sources. In addition to their large energies, gamma rays have great penetrating power that permits them to reach the Solar System from essentially any portion of the Galaxy or the Universe. The Earth's atmosphere is, however, opaque to gamma rays, making this a space-based research field.

Observations of cosmic gamma rays allow the study of such diverse astrophysical problems as the formation of elements in the Universe, the structure and dynamics of the Galaxy, the radiation mechanisms of pulsars, the energy sources of quasars, the search for black holes, the origin of gamma-ray bursts, and the possible existence of large amounts of antimatter in the Universe. In many cases, gamma rays are the only source of information about the high energy aspects of such phenomena.

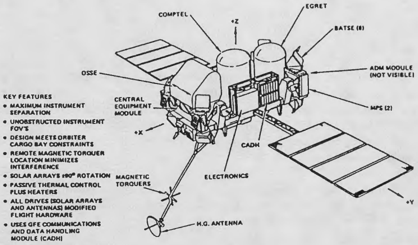

Figure 1 - The Gamma Ray Observatory

THE GAMMA RAY OBSERVATORY

Although a number of smaller space missions have carried gamma-ray telescopes, the Gamma Ray Observatory (GRO) will be the first comprehensive exploration of this high-energy view of the universe. The GRO is a 16,000 kg spacecraft (Figure 1) which provides an oriented platform for a complement of four instruments whose observations will span 6 decades of energy, from 0.03 MeV (million electron volts) to 30,000 MeV. This broad energy range, and the fact that gamma rays cannot be focused with lenses or mirrors, necessitates the use of separate instruments which use a number of detection techniques. The instruments are:

Burst and Transient Source Experiment (BATSE)

BATSE is designed to monitor a large fraction of the sky continuously for a variety of transient gamma-ray events, including gamma-ray bursts, solar flares, and variable stars and galaxies. The instrument consists of eight wide-field scintillator modules, one located at each corner of the spacecraft, for maximum continuous exposure to the sky. Each module also contains a spectroscopy detector for better energy resolution at reduced sensitivity.

Oriented Scintillation Spectrometer Experiment (OSSE)

OSSE utilizes four large actively-shielded and passively collimated Sodium Iodide scintillation detectors to provide excellent sensitivity for both gamma-ray line and continuum radiation. An offset pointing system modulates the celestial source contributions to allow background subtraction. OSSE's targets will include x-ray sources, the Galactic Center, black hole candidates, and active galaxies.

Imaging Compton Telescope (COMPTEL)

COMPTEL is based on a two-step gamma-ray detection process, in which the gamma ray first scatters in a liquid scintillator detector and then is absorbed in a Sodium Iodide crystal. With its extremely wide field of view and good spatial resolution, COMPTEL will study sources at intermediate gamma-ray energies, including pulsars, active galaxies, and galactic features.

Energetic Gamma-Ray Experiment Telescope (EGRET)

EGRET, which covers the highest part of the GRO energy range, uses a multiple layer spark chamber and thin metal plates to detect gamma rays which undergo electron-positron pair production. A large Sodium Iodide detector is used to measure the energies. Like COMPTEL, EGRET has a wide field of view. It will investigate a wide variety of topics, including active galaxies, the extraglactic diffuse radiation, pulsars, and galactic structure.

Figure 2 shows how the four GRO instruments combine to cover the broad energy range. The figure also indicates how some of the astrophysical problems span several or all of the instrument energy ranges.

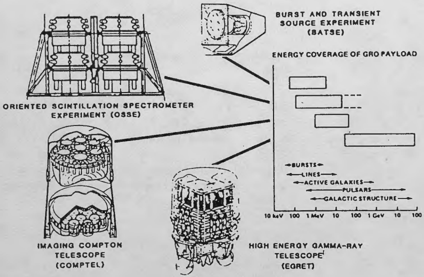

Figure 2 -- Energy coverage of the GRO payload

THE GAMMA RAY OBSERVATORY MISSION

GRO is scheduled for an April 1991 launch by the Shuttle Atlantis. The Shuttle will carry the observatory to an altitude of 450 km and remain nearby until the GRO is operational. An on-board propulsion system will maintain this altitude, which is optimized for the scientific return, for the life of the mission, planned for 2 years and possibly extending to 4 or more years. At the end of the mission, the GRO could be retrieved by the Shuttle, or its propulsion system could be used to control the re-entry.

The first scientific goal of the mission is to conduct an all-sky survey with the COMPTEL and EGRET instruments while pointing OSSE to a list of priority targets (BATSE will monitor the entire sky throughout the mission). After this first comprehensive mapping of the gamma-ray sky, expected to take about 15 months, GRO will return to selected target regions for the continuing mission. Guest Investigators have been invited to participate in most aspects of the mission after the all-sky survey.