SOURCE DETECTIONS USING GALEX MISSION IN NEAR-FAR UV BANDS IN CAT EYE NEBULA

PROJECT REPORT

In partial fulfillment of the requirement for the award of
Master of Science in Physics

Submitted by

ATHIRA C

M.Sc Physics

Register number-210011013000

MAHATHMA GANDHI UNIVERSITY, KOTTAYAM

S.N.M. COLLEGE, MALIANKARA

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BONAFIDE CERTIFICATE

This is to certify that the project entitled **"SOURCE DETECTIONS USING GALEX MISSION IN NEAR-FAR UV BANDS IN CAT EYE NEBULA"** submitted by **ATHIRA C** (Register number: **210011013000**), for the award of the Masters degree under Mahatma Gandhi University, Kottayam in the Department of Physics is a bonafide record of the work carried out and completed successfully under my guidance and supervision at S.N.M. College, Maliankara.

Name and address of the Project Guide

L S Bose 15/9/23

Dr. Lakshmi S Bose

Assistant Professor

Department of Physics

S.N.M. College, Maliankara

DEPARTMENT OF PHYSICS
S.N.M COLLEGE
MALIYANKARA
N.PARAVUR-683 516

Institution/Department Seal

To
The Principal
S.N.M. College, Maliankara

Copy to HoD

TO WHOMSOEVER IT MAY CONCERN

Sub: Sanction Letter

This is a reference to your letter dated on 05/12/2022 we are pleased to accept your letter and provide permission for doing a project entitled " SOURCE DETECTIONS USING GALEX MISSION IN NEAR-FAR UV BANDS IN CAT EYE NEBULA " at our concern for **ATHIRA C** of S.N.M. College Maliankara for the period from 04/01/2023 to 07/07/2023 under my guidance.

With best wishes

Name and address of the Project Guide

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Office/Department Seal

CERTIFICATE

This is to certify that the project entitled **"SOURCE DETECTIONS USING GALEX MISSION IN NEAR-FAR UV BANDS IN CAT EYE NEBULA"** is a bonafide work done by **ATHIRA C** under my guidance and supervision and this project was carried out in partial fulfillment of the requirement for the award of Master of Science in Physics.

Examiners:

Dr. Sujatha N V

Dr. Riju K Thomas

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DECLARATION

I hereby declare that the project report entitled **"SOURCE DETECTIONS USING GALEX MISSION IN NEAR-FAR UV BANDS IN CAT EYE NEBULA"** was written and submitted by me under the guidance of **Dr. Lakshmi S Bose,** Assistant Professor, Department of Physics. I also declare that, this project report has not been submitted at any time to any other university or Institute for the award of any degree or diploma.

ATHIRA C
MSc Physics
SNM College Maliankara

Sree Narayana Mangalam College, Maliankara

(Affiliated to Mahatma Gandhi University, Kottayam)
Ernakulam[i] - 683516

Vision

Vision of the College is, in unison with the vision of the Great Sree Narayana Guru, to liberate the weak and the oppressed of the society through education and to teach them to stand together and work together to attain excellence in their own and their fellow men's live.

Mission

The academic community of the college is totally committed to help evolve a new generation of young people who are just, kind and responsible ageneration which is committed to social reconstruction. Our thrust is on the creation of such youngsters who have learned the skills of working together in the rhythm of love and mutual understanding to attain our social goals of liberty and equality. They should also have the moral integrity to take the lead flag of social harmony in our social fabric that tears off easily.

Core Values

- Pursuit of Excellence
- Integrity
- Diversity
- Compassion

ABSTRACT

The current study is the Source Detections using GALEX mission in Near-Far UV Bands in Cat Eye Nebula. We have measured the number of FUV & NUV Sources from 6 deep imaging Surveys of GALEX in the nebula and noted its fluxes in the catalog given using Fits Viewer. We have plotted number of UV sources against its AB magnitude for each tile in FUV and NUV bands. Our results are in good agreement with the previous studies only up to the level of magnitude less than +22.0. But one of the surveys in Cat's Eye does not follow Gaussian profile due to overestimation of fluxes in source catalog. This is because DIS observations of GALEX are 80% complete to NUV magnitude of 23.0 and FUV magnitude of 23.5, hence the source confusion is significant in these observations. We have also noted that the number counts of UV sources at fainter side (AB mag> 23is not detected by GALEX and is identified as one of the limition of GALEX mission.

CONTENTS

CHAPTER 1......2

1.INTRODUCTION......2

2.CELESTIAL OBJECTS......2

3.RESEARCH IN ASTROPHYSICS......4

4.ULTRAVIOLET ASTRONOMY......5

5.ASTRONOMICAL COORDINATE SYSTEM......7

CHAPTER 2......11

1.SATELLITE USED FOR THE STUDY :GALAXY EVOLUTION EXPLORER......11

2.GALEX SCIENCE SURVEYS......13

3.IMAGING SURVEYS......14

4.SPECTROSCOPIC SURVEYS......15

5.GALEX LEGACY SURVEYS......16

6.KEY DISCOVERIES......17

CHAPTER 3......19

1.CAT'S EYE NEBULA AND OBSERVATIONS OF GALEX......19

2.GALEX OBSERVATIONS IN CAT'S EYE NEBULA......22

3.GALEX UV SURVEYS......22

CHAPTER 4......25

1.METHODOLOGY......25

2.RESULTS AND DISCUSSIONS......29

3.REFERENCES......32

CHAPTER I

INTRODUCTION

Astronomy, a branch of science deals with studying celestial objects like stars, planets, nebulas, comets, constellations, galaxies etc. It tells the physics of stellar bodies and the formation of the early and current universe. Theoretical astronomy deals with theory based models of the universe. It allows us to analyze the way in which the celestial system has evolved. But the observational one focuses on information from telescopes; spectrometers etc and we have to analyze it. Like astronomy, Astrophysics is a branch that applies the laws of physics and chemistry to explain the birth, evolution and death of stars, planets, galaxies, constellations and other celestial objects in the universe. Current scientific research in astrophysics utilizes information from ground based and space based telescopes for better understanding of celestial objects and the universe.

CELESTIAL OBJECTS

The celestial object is a complex, less cohesively bound structure consisting of multiple bodies or even objects with substructures.

A Star is a form of celestial object, starting its life with the gravitational collapse of a gaseous nebula of material composed mostly of hydrogen, along with helium and a small amount of heavier elements. There are billions of stars in our Milky Way galaxy including our own sun. And there are billions of galaxies in the universe. Stars come in many different types and sizes from smoldering white dwarf to blazing red giants. The physical characteristics like mass, brightness, radius, surface temperature that vary for each of different types of stars

A galaxy is any of the system of stars, stellar fragments, dust matter, interstellar gas and dark matter. Literal meaning of galaxy is "milky" which is originated from the Greek word galaxies. Galaxies usually seen in clusters, some of which are in grouped into larger clusters that measure hundreds of millions of light - years. Our galaxy the Milky way consists of billions more stars, all held together by gravity. The Milky way has a spiral shape, like more than two-thirds of the known galaxies. Some galaxies have elliptical shapes and a few have unusual shapes like toothpicks or rings. Majority galaxies have black holes at their centers that produce huge amounts of energy, which astronomers can see over great distances. In some galaxies its central black hole is extremely large, compared with small galaxies. Galaxies can be classified by their shape as elliptical galaxies, spiral and irregular galaxies. Each type has different characteristics and a different history of evolution.

A planet is a body that revolves around a star generally classified into two types: Terrestrial Planets and Gas Giants. Planets that orbit other stars are referred to as exoplanets. In our solar system, the inner four planets closest to the sun are rocky (Mercury, Venus, Earth and Mars) are called terrestrial planets. Jupiter, Saturn, Uranus and Neptune – the four larger outer planets are called gas giants.

A nebula is an interstellar cloud of dust, hydrogen, helium and other ionized gases. Most nebulae are of vast size; some are hundreds of light years in diameter. A nebula that is barely visible to the human eye from Earth would appear larger, but no brighter, from close by. The Orion Nebula, the brightest nebula in the sky and occupying an area twice the diameter of the full Moon, can be viewed with the naked eye but was missed by early astronomers. Although denser than the space surrounding them, most nebulae are far less dense than any vacuum created on Earth. Many nebulae are visible due to fluorescence caused by embedded hot stars, while others are so diffuse they can only be detected with long exposures and special filters. Some nebulae are variably illuminated by T Tauri variable stars. Nebulae are often star-forming regions, such as in the "Pillars of Creation" in the Eagle Nebula. In these regions the formations of gas, dust, and other materials "clump" together to form denser regions, which attract further matter, and eventually will become dense enough to form stars. The remaining material is to form planets and other planetary system objects.

There are a variety of formation mechanisms for the different types of nebulae. Some nebulae form from gas that is already in the interstellar medium while others are produced by stars. Examples of the former case are giant molecular clouds, the coldest, densest phase of interstellar gas, which can form by the cooling and condensation of more diffuse gas.

Examples of the latter case are planetary nebulae formed from material shed by a star in late stages of its stellar evolution.

Star-forming regions are a class of emission nebula associated with giant molecular clouds. These form as a molecular cloud collapses under its own weight, proceeding stars. Massive stars may form in the center, and their ultraviolet radiation ionizes the surrounding gas, making it visible at optical wavelengths. The region of ionized hydrogen surrounding the massive stars is known as an H II region while the shells of neutral hydrogen surrounding the H II region are known as photo dissociation region. Examples of star-forming regions are the Orion Nebula, the Rosette Nebula and the Omega Nebula. Feedback from star-formation, in the form of supernova explosions of massive stars, stellar winds or ultraviolet radiation from massive stars, or outflows from low-mass stars may disrupt the cloud, destroying the nebula after several million years.

Other nebulae form as the result of supernova explosions; the death throes of massive, short-lived stars. The materials thrown off from the supernova explosion are then ionized by the energy and the compact object that its core produces. One of the best examples of this is the Crab Nebula, in Taurus. The supernova event was recorded in the year 1054 and is labeled SN 1054. The compact object that was created after the explosion lays in the center the Crab Nebula and its core is now a neutron star.

RESEARCH IN ASTROPHYSICS

The study of Astrophysics, understanding the universe in which we live has been an exciting field of exploration from centuries onwards. The fundamental questions in celestial bodies, galaxies etc are wanted to be solved before those centuries. It is this attempt to answer these questions and mysteries about the universe the way of research in astrophysics. Remarkable discoveries have been made in recent times starting from Big Band theory to measurement of large-scale structures in the universe, the existence of dark matter, Dark energy, the discovery of planets around other stars etc. Observations in the universe are carried out mostly with telescopes, not only familiar ones sensitive to optical light rays, but also with instruments designed to receive radio waves, X ray and Gamma rays.The vast amount of observational details obtained using these techniques are analyzed and then interpreted by means of basic laws of physics. The important reason to study astronomy is to satisfy our fundamental curiosity about the world we live in. When Copernicus claimed that Earth was not the centre of universe, but it is Sun, which triggered a revolution .It is through these types of revolutions, our science and society adapted this new world view. Astronomy technology helps to address real world problems here on Earth and outside. The technologies and techniques developed in the field of astronomy gave solutions on commercially relevant issues and provide much information and guidance on how academics and industry can collaborate to develop future applications. The vast technological development in astronomy, especially in areas such as optics and electronics, have become essential to our day to day life with applications such as satellites, Global position system, Communication satellites, Solar panels .

Topics studied by theoretical astrophysicists include stellar dynamics and evolution, galaxy formation and evolution, magneto hydrodynamics, large scale structure of matter in the universe, origin of cosmic rays, general relativity and physical cosmology and astroparticle physics. Research in astrophysics is an infinite process. Active areas of current research mainly include the structure and evolution of stars, nuclear physics, astrophysical fluid dynamics, radioactive processes, the formation and structure and evolution of galaxies, physical and early universe cosmology.

ULTRAVIOLET ASTRONOMY

Since the earth's atmosphere absorbs much of high energy ultraviolet radiation, scientists utilizes the data from satellites positioned above the atmosphere in orbit around our earth, to sense UV radiation coming from the sun and other types of astronomical objects. It helps to study the formation of stars in ultraviolet since young stars shine most of their light at these wavelengths. Generally there are different subdivisions of ultraviolet radiation and they are Near Ultraviolet (NUV), Middle Ultraviolet (MUV), Far Ultraviolet (FUV) and Extreme Ultraviolet(EUV).Scientists can study the formation of stars in ultraviolet since young stars shine most of their light at these wavelengths

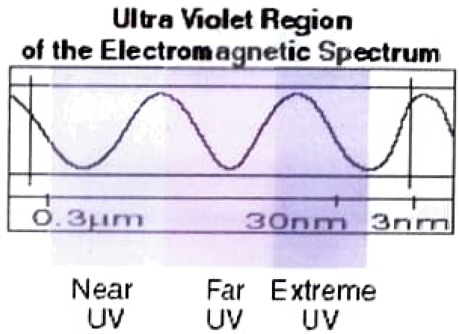


Fig:1 UV range in electromagnetic spectrum

Observations in Ultraviolet band (UV range: 3 nm - 0.4 μm), is highly used in many astronomical problems including planetary science, interstellar and intergalactic media, physical and chemical processes involved in the formation of stellar objects, evolution of galaxies and cosmological studies. Detailed study of interstellar and intergalactic phenomena can be accomplished through UV observations. Since electronic transitions of abundant molecules belonged to this range, such studies enable the understanding of physical properties and chemical reactions taking place in the stars and galaxies. Furthermore UV observations are particularly interesting because the Lyman break is red shifted into the far and near ultraviolet (hereafter, NUV & FUV) for distant objects. The instantaneous rate of star formation in these galaxies are particularly difficult to 1 discern otherwise. Hence UV observations enable to expand the frontiers of our envelope of knowledge about distant galaxies including active galactic nuclei (AGNs) associated with black holes. Most of the UV radiation is from hot, massive, O and B stars that have peak spectral energy distributions in the UV band. Hence, the study of number counts of resolved UV galaxies provides information regarding the history of extragalactic star formation. The UV is also important physically in that most of the energy of the stellar radiation is in the UV range and absorption of this radiation by the dust grains powers the infrared emission. Hence, the observations of diffuse ultraviolet radiation, track the transfer of radiation from the stars to the Interstellar Medium. The studies of diffuse UV sky have been an important part of interstellar dust studies over the last four decades though the difficulty of observing faint diffuse sources near the limit of the instrumental sensitivity has been a limitation. Earlier observations in UV have been patchy in both distribution and quality and it is only recently that large scale observations of the diffuse UV sky are emerging.

Ultraviolet astronomy is the study of celestial objects by means of ultraviolet radiation they emit and the UV observations can also produce information about the evolution of galaxies. The UV rays can be very harmful to life because they are strong enough to ionize atoms and destroy cells. But earth's atmosphere shields us from most of UV radiation. Astronomers who want to study UV light from celestial sources must do so from space -borne telescope such as Hubble Space Telescope, Galaxy Evolution Explorer (GALEX etc. There are mainly three astronomical facilities working in the UV range: The Hubble Space Telescope (HST), The Galaxy Evolution Explorer (GALEX) and Far Ultraviolet Spectroscopic Explorer (FUSE).HST and FUSE are observatory missions while GALEX is mainly devoted to carry out first all-sky UV survey .Hubble Space Telescope is a space based observatory that observes at ultraviolet through near infrared wavelengths. High resolution imaging and wide ranging spectroscopic capabilities enable forefront research across all domains of astrophysics which was launched into low earth orbit in 1990.The Far Ultraviolet Spectroscopic Explorer was a NASA astrophysics telescope whose purpose was explore the universe using the technique of high resolution spectroscopy in the far ultraviolet spectral region which was launched on June24, 1999 and operated until October 18 2007.

ASTRONOMICALCO ORDINATESYSTEM

A coordinate system is a method of indicating positions. Each coordinate is a quantity measured from some starting point along some curve or line, termed as coordinate axis. In the field of astronomy, a celestial coordinate system is a system which helps to specify the position of planets, stars, galaxies etc. There are basic astronomical coordinate systems: ecliptic coordinate system, galactic coordinate system and equatorial coordinate system.

Equatorial Coordinate System

The equatorial coordinate system is the most commonly used astronomical coordinate system for indicating the position of stars or other celestial objects on a celestial sphere. Celestial sphere is an imaginary sphere with the observer at its center. To designate the position of a star, consider an imaginary great circle passing through the celestial poles and through the star consider. This is a star hour circle, analogous to a meridian of longitude on earth. Then measure the angle between the vertical equinox and the point where the hour circle intersects the celestial equator. This angle is termed as the star's right ascension and it is measured in hour, minute and seconds. Observer measures along the star's hour circle the angle between the celestial equator and the position of the star. This angle is termed as declination of the star and it is measured in degrees, minutes, and seconds north or south of the celestial equator analogous to latitude on earth. The right ascension is always measured eastward from the vertical equinox. Right ascension and declination together helps to determine the location of a star on the celestial sphere. In the equatorial coordinate system, the Earth equator is the plane of reference. The celestial sphere is as large as the known universe, and Earth is the center of this sphere. The great circle on the celestial sphere halfway between the celestial poles is called the celestial equator. The reference point on the celestial equator is the vertical equinox, which is the point at which the Sun crosses the celestial equator.

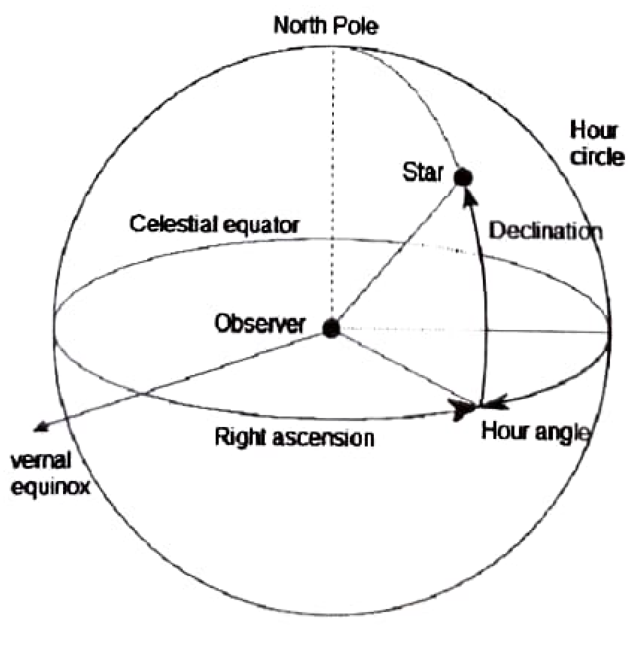


Fig:2 Equatorial Coordinate System

Galactic Coordinate System

Galactic coordinate system is astronomical coordinate system in which the galactic plane is considered an equator. North galactic pole and the zero point on the galactic equator are the reference points and its galactic longitude and galactic latitude are the coordinates of a celestial body. In the galactic coordinate system, positions of objects are measured in terms of their galactic longitude and galactic latitude. Galactic longitude measured in degrees is the eastward of an imaginary line running across the plane of the galaxy and connecting Earth. This system defines a sphere enclosing the galaxy, with sun at its centre, onto which galactic latitude and longitude are projected. Galactic latitude ranges from -90° to 90°whereas galactic longitude ranges from 0° to 360°. This system uses the right-handed conversion meaning that coordinates are positive towards the north and towards the east in the fundamental plane.

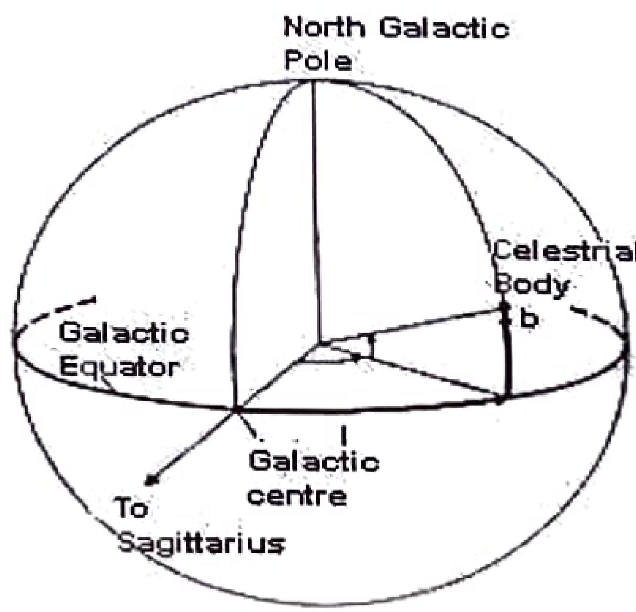


Fig:3 Galactic Coordinate System

Ecliptical Coordinate System

Ecliptical coordinate system, in which the origin of the system can be the center of either the Earth or Sun, its primary direction is towards the vertical equinox and it has a right hand conversion. The Ecliptical poles are the two points at which a line perpendicular to the plane of the ecliptic through the center of the Earth strikes the surface of the celestial sphere. This system is commonly used to represent the apparent positions and orbits of solar system objects. Here the fundamental reference circle is the ecliptic and the zero point is the vertical equinox. Ecliptic longitude measures the angular distance of an object along the ecliptic from the primary direction. Primary direction points from the Earth towards the Sun at the vertical equinox of the northern hemisphere. Ecliptic longitude is measured positive eastwards in a fundamental plane from 0° to 360°. Ecliptic latitude measures the angular distance of an object from the ecliptic toward the north or south ecliptic pole, measured along the great circle through the body and the pole of the ecliptic. Ecliptic longitude is measured eastward along the ecliptic to the intersection of the body's circle of longitude; which is measured in the same direction as the Sun's apparent annual motion.

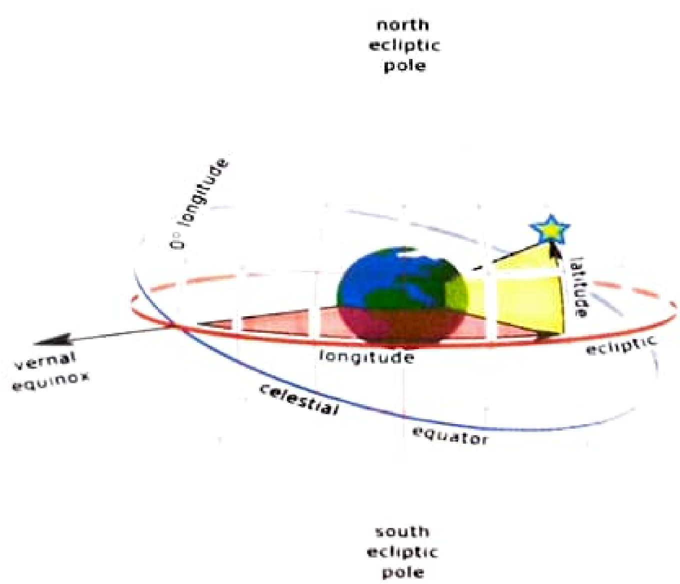


Fig:4 Ecliptic Coordinate System

CHAPTER II

SATELLITE USED FOR THE STUDY: GALAXY EVOLUTION EXPLORER (GALEX)

There is a strong absorption of UV radiation by Earth's atmosphere. Spacecraft missions promise to overcome this limitation to achieve astronomical objectives. A series of UV telescopes have been launched on spacecraft in early 1960's, for the measuring of UV radiations from the Sun. The most successful one is the International Ultraviolet Explorer (IUE) launched in 1978. The IUE is also used to study more about stars, galaxies and other celestial objects. It has recorded more information about novae and supernovae. It is succeeded by the Extreme Ultraviolet Explorer (EUVE) launched in 1992. Due to technological enhancement, UV satellite missions have achieved better resolution and greater sensitivity. Currently, observations from three major astronomical facilities such as Hubble Space Telescope (HST), Far Ultraviolet Spectroscopic Explorer (FUSE) and Galaxy Evolution Explorer (GALEX) are available in UV. Of these, GALEX is dedicated to conduct the first all-sky UV survey.

The Galaxy Evolution Explorer (GALEX)[1] was an orbiting space Telescope that was to observe the cause and formation of stars in galaxies in ultraviolet wavelength built by Orbital Sciences Corporation(OSC) for NASA.GALEX was launched by a Pegasus -XL vehicle on April 28 2003 into a 690 km altitude ,29 degree inclination ,circular orbit with a 98.6 minute period .The GALEX instrument allows imaging and spectroscopic observations to be made in two ultraviolet bands, Far UV (FUV) 1350-1780Å and Near UV (NUV) 1770-2730Å. The instrument provides simultaneous co-aligned FUV and NUV images with spatial resolution 4.3 and 5.3 arc seconds respectively.

[1]http://www.galex.caltech.edu/

Fig: 5 Galaxy Evolution Explorer

It was designed to fit into the nose cone of a Pegasus launch vehicle and so began its journey with its solar panels wrapped around spacecraft. So when it reached orbit around the Earth it was only 1.1 meter wide. It can see light wavelengths from 135 nm to 280 nm with a field of view of 1.2 degree wide. The batteries and solar panel that gave necessary power to the spacecraft and telescope have a lifetime of 12 years and the orbit of GALEX is stable for at least 25 years after launch. Although originally planned as a 29 month mission, the NASA Senior Review Panel in 2006 recommended that the mission life time be extended to almost 9 years with NASA to 7 February 2012.

The Galaxy Evolution Explorer specializes in surveying galaxies in ultraviolet light. Its telescope, 50 centimeters (19.7 inches) in diameter, has a field of view that is much wider than most ground-based and space-based telescopes. This field of view, nearly three times the diameter of the Moon, allowed the Galaxy Evolution Explorer to discover seemingly newborn galaxies in our local universe.

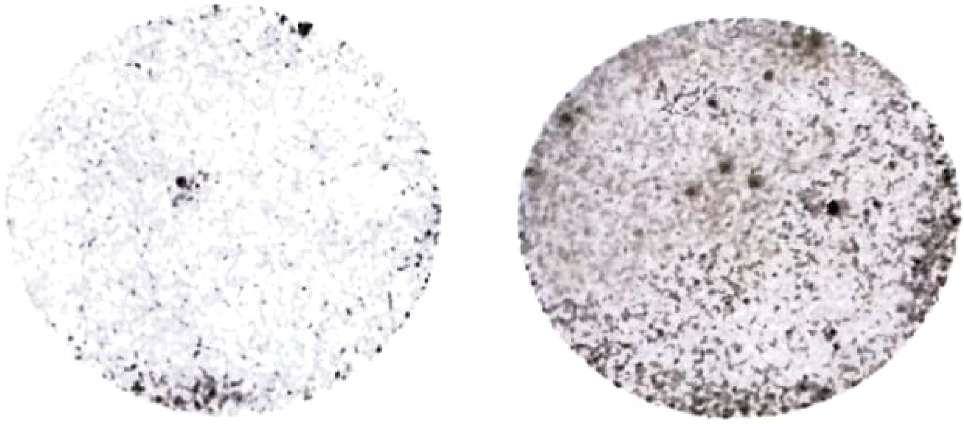


Fig: 6 a. GALEX FUV and NUV Image

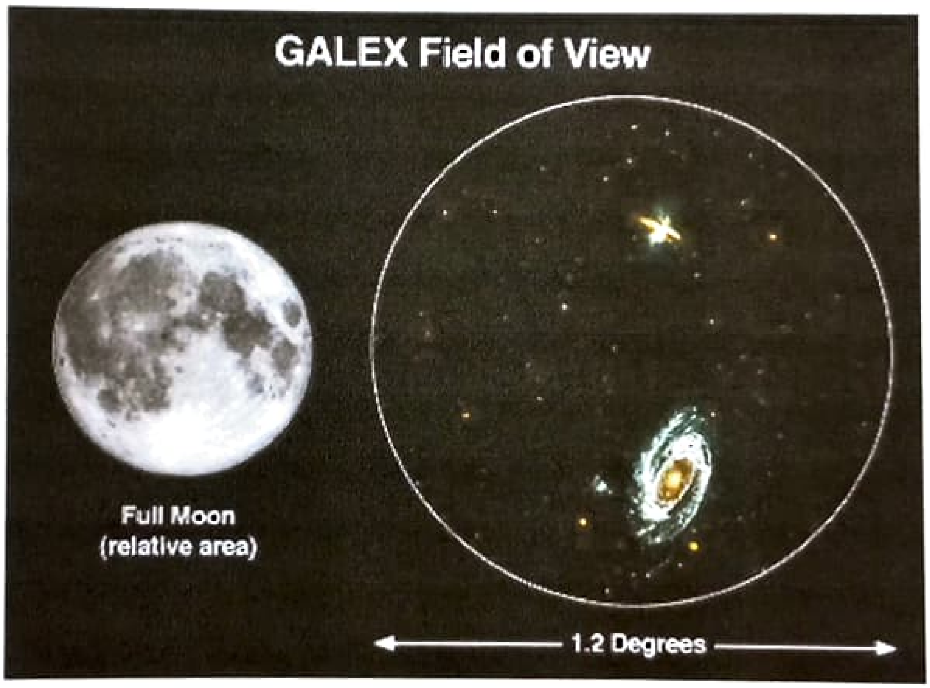


Fig:6 b.GALEX Field of View of 1.2 degrees

GALEX Science Surveys

The science goals of the GALEX mission are achieved with a series of nested surveys. Observations of many survey types are made each day (14 to 15 eclipses), although only one survey type can be assigned to each eclipse. The baseline mission surveys were completed in the Fall of 2007 and are shown in the table below along with the number of tiles released at MAST in 2007 (GR2/3), 2008 (GR4), and 2010 (GR6).

GALEX Baseline Mission Surveys completed in Fall 2007					
Survey	Exposure Time (seconds)	Sky Coverage (deg^2)	Depth (m_{AB})	GR2/3 tiles	GR4 tiles
All-sky Imaging (AIS)	100	26,000	20.5	15721	28,000**
Medium Imaging (MIS)	1,500	1,000	23.5	1017	1615
Deep Imaging (DIS)	30,000	80	25.0	165	193
Nearby Galaxy (NGS)	1,500	300	28*	296	433
Medium Spectroscopic (MSS)	150,000	5	22	3	5**

Imaging Surveys

Deep Imaging Survey (DIS) - Exposure goal of 30,000s over 80 square degrees of sky. Targets are chosen to have extensive corollary data from other large surveys like COSMOS, DEEP and ELAIS.

Medium Imaging survey (MIS) - Single orbit exposures (1,500s) of 1000 square degrees in positions that match the Sloan Digital Sky Survey (SDSS) spectroscopic footprint. The MIS has been extended to cover the Two Degree Field Galaxy Redshift Survey (2dFGRS) and the AA-Omega (WiggleZ) project.

All-Sky Imaging Survey (AIS) - Exposure time of 100s over 26,000 square degrees of sky reaching a depth of mAB = 20-2 in both bands. The large sky coverage is achieved by observing a chain of up to 12 positions in a single eclipse. The pointing centers are chosen from a fixed grid of points on the sky that were chosen to avoid having many gaps between adjacent fields. Areas within 20 degrees of the Galactic plane have patchy coverage due to detector safety limits on the total UV sky brightness in the instrument field of view. GR4/5 contains a total of 28,269 individual pointing's.

Nearby Galaxy Survey (NGS) - This is a survey targeting nearby galaxies with a nominal exposure time of 1000s to 1500s. Note that some fields have significantly more exposure time. The core of the NGS targets the 71 galaxies included in the Spitzer Nearby Galaxies Survey (SINGS). However, the sample also includes a variety of nearby galaxies, typically included due to existing or planned data at other wavelengths. Thus, the NGS is not a statistically representative sample of the galaxies in the local universe. The GR4/5 release contains a total 458 pointing's.

Spectroscopic Surveys

In addition to the imaging data, there is limited amount of spectroscopy available. The original plan for the spectroscopic surveys was similar to that for the imaging, with shallow exposures covering large areas and progressively deeper exposures targeting smaller solid angles. However, as the mission progressed, the decision was made to only continue with the Medium Spectroscopic Survey. Below are the three classes of spectroscopic data sets available in the GR2/GR3 releases.

Medium Spectroscopic Survey (MSS) - Spectroscopic observations with exposure goal of 150,000s covering 5 square degrees of fields observed as a part of the Deep Imaging Survey.

Calibration Spectroscopy (CAS) - GALEX has observed several white dwarf standards for the purposes of calibration. In contrast to the imaging, most of these standards are not saturated in spectroscopy.

GALEX Legacy Surveys

A brief summary of the GALEX legacy surveys is presented in the table below.

GALEX Legacy Surveys			
Survey		Exposure Time (seconds)	Sky Coverage (deg^2)
Galactic Cap Survey	SDSS Galactic cap footprint	1,500	20,000
Legacy Deep Survey	PS-1, M31, SDSS	30,000	100
Milky Way Survey	SEGUE	1,500	5,000
Legacy Spectroscopy Project	SDSS	150,000	20
Deep Galaxy Survey	Nearby Galaxies	15,000	100
Ultra Deep imaging Survey		300,000	7

Summary of GALEX Characteristics

Item	FUV band	NUV band
Bandwidth	1350 – 1750 Å	1750 – 2850Å
Effective wavelength	1528 Å	2271 Å
Field of view	$1^0.28$	$1^0.24$
Image resolution	4.3″	5.3″
Sky background	2000counts/second	2000counts/second
Limiting magnitude		
AIS	19.9	20.8
MIS	22.6	22.7
DIS	24.8	24.4
Pipeline image format	3840×3840 elements with 1.5″	3840×3840 elements with 1.5″

The primary goal of GALEX is to address these questions:

- What are the ultraviolet properties of local galaxies, and how do rest ultraviolet properties, measured at high redshift by HST and NGST in their search for galaxy origin related to star formation rate (SFR), extinction, metallicity and burst history?
- What is the star formation and metal production history of galaxies over the red shift range 0<z<2? When and where did stars and elements we see today have their

origins? And does this history explain the dramatic evolution suggested in previous surveys?

- What global factors drive star formation and its evolution in galaxies?

Key Discoveries

The Galaxy Evolution Explorer captures the most sensitive and comprehensive image ever taken of the Andromeda galaxy, our nearest large neighbor galaxy.

The Galaxy Evolution Explorer captures a giant star eruption, or flare, about one million times more energetic than those from our Sun.

The Galaxy Evolution Explorer spots what appear to be massive "baby" galaxies in our corner of the universe, suggesting our aging universe is still alive with youth.

Findings from The Galaxy Evolution Explorer indicate that supermassive black holes in some giant galaxies create such a hostile environment; they shut down the formation of new stars.

The Galaxy Evolution Explorer's observations allow scientists for the first time to see the process of a black hole eating a star.

Observations from the Galaxy Evolution Explorer prove the "nature" theory of galaxy evolution, which holds that galaxies are evolutionarily linked.

The Galaxy Evolution Explorer identifies dwarf galaxies forming out of nothing more than pristine gas likely leftover from the early universe, rather than in association with dark matter or gas containing metals.

Astronomers, using data from the Galaxy Evolution Explorer, find that galaxies presumed "dead" and devoid of star-making can be reignited with star birth, and that galaxy evolution does not proceed straight from the cradle to the grave.

Astronomers come up with a new way to identify planets beyond our solar system based on the Galaxy Evolution Explorer's use of ultraviolet imaging.

The Galaxy Evolution Explorer and the Anglo-Australian Telescope on Siding Spring Mountain in Australia complete a five-year survey of 200,000 galaxies stretching back seven billion years in cosmic time. The results lead to one of the best independent confirmations that dark energy is driving our universe apart at accelerating speeds.

The Galaxy Evolution Explorer (GALEX) has photographed hundreds of millions of galaxies in ultraviolet light. M106 is one of those galaxies, and from 22 million light years away, it strikes a pose in blue and gold for this new commemorative portrait.M106, also known as NGC 4258, is located in the constellation Canes Venatici. This image is a two-color composite, where far-ultraviolet light is blue, and near-ultraviolet light is red. The galaxy's extended arms are the blue filaments that curve around its edge, creating its outer disk. Tints of blue in M106's arms reveal hot, young massive stars. Traces of gold toward the center show an older stellar population and indicate the presence of obscuring dust.

"We see these arms in optical-light images, but they are very faint and diffuse. These structures really pop out in the ultraviolet due to the exquisite sensitivity of the detectors on the Galaxy Evolution Explorer and is the best.

CHAPTER III

CAT'S EYE NEBULA & OBSERVATIONS OF GALEX

The current study was conducted in Cat's Eye Nebula and observations were taken from GALEX satellite. The Cat's Eye was the first planetary nebula to be observed with a spectroscope by William Huggins on August 29, 1864. Huggins' observations revealed that the nebula's spectrum was non-continuous and made of a few bright emission lines, first indication that planetary nebulae consist of tenuous ionized gas. Spectroscopic observations at these wavelengths are used in abundance determinations, while images at these wavelengths have been used to reveal the intricate structure of the nebula.

NGC 6543 is a high northern declination deep-sky object. It has the combined magnitude of 8.1, with high surface brightness. Its small bright inner nebula subtends an average of 16.1 arcsec, with the outer prominent condensations about 25 arcsec. Deep images reveal an extended halo about 300 arcsec or 5 arcminutes across, that was once ejected by the central progenitor star during its red giant phase.

NGC 6543 is 4.4 minutes of arc from the current position of the north ecliptic pole, less than 1⁄10 of the 45 arcminutes between Polaris and the current location of the Earth's northern axis of rotation. It is a convenient and accurate marker for the axis of rotation of the Earth's ecliptic, around which the celestial North Pole rotates. It is also a good marker for the nearby "invariable" axis of the solar system, which is the center of the circles which every planet's north pole, and the north pole of every planet's orbit, make in the sky. Since motion in the sky of the ecliptic pole is very slow compared to the motion of the Earth's north pole, its position as an ecliptic pole station marker is essentially permanent on the time-scale of human history, as opposed to the pole star, which changes every few thousand years.

Observations show the bright nebulosity has temperatures between 7000 and 9000 K, whose densities average of about 5000 particles per cubic centimetre. Its outer halo has the higher temperature around 15,000 K, but is of much lower density. Velocity of the fast stellar wind is about 1900 km/s, where spectroscopic analysis shows the current rate of mass loss averages $3.2\times10{-}7$ solar masses per year, equivalent to twenty trillion tons per second (20 Eg/s).

Though the Cat's Eye Nebula was one of the first planetary nebulae to be discovered, it is one of the most complex such nebulae ever seen. Planetary nebulae form when Sun-like stars gently eject their outer gaseous layers, creating amazing and confounding shapes. The Cat's Eye Nebula, also known as NGC 6543, is a visual "fossil record" of the dynamics and late evolution of a dying star. It is estimated to be 1,000 years old.

In 1994, initial Hubble observations revealed the nebula's surprisingly intricate structures, including gas shells, jets of high-speed gas, and unusual shock-induced knots of gas. Subsequent Hubble images showed a bull's-eye pattern of eleven or more concentric rings, or shells, of dust around the Cat's Eye. Each "ring" is actually the edge of a spherical bubble seen projected onto the sky — that's why it appears bright along its outer edge.

Observations suggest the star that created the Cat's Eye Nebula ejected its mass in a series of pulses at 1,500-year intervals. These convulsions created dust shells, each of which contains as much mass as all of the planets in our solar system combined (still only one percent of the Sun's mass). These concentric shells make a layered, onion-skin structure around the dying star. The view from Hubble is like seeing an onion cut in half, where each skin layer is discernible.

Approximately 1,000 years ago the pattern of mass loss suddenly changed, and the Cat's Eye Nebula began forming inside the dusty shells. It has been expanding ever since, as discernible in comparing Hubble images taken in 1994, 1997, 2000, and 2002. But what caused this dramatic change? Many aspects of the process that leads a star to lose its gaseous envelope are still poorly understood, and the study of planetary nebulae is one of the few ways to recover information about these last few thousand years in the life of a Sun-like star.

Until recently, it was thought that shells around planetary nebulae were a rare phenomenon. However, Romano Corradi of the Isaac Newton Group of Telescopes in Spain and his collaborators instead used Hubble to show that the formation of these rings is likely to be the rule rather than the exception. In 2013, Martin A. Guerrero, of the Instituto de Astrofisica de Andalucia in Spain, used Hubble to study the temperature and density of the Cat's Eye Nebula's shells. He found that the shells represent a series of shocks propagating into pre-existing lower density material.

Several explanations have been proposed for the bull's-eye patterns seen around planetary nebulae, including cycles of magnetic activity somewhat similar to our own Sun's sunspot cycle, the action of a companion star orbiting aroundthe dying star, and stellar pulsations. Another school of thought is that the material is ejected smoothly from the star, and the rings are created later on due to the formation of waves in the out flowing material. Further observations and more theoretical studies are needed to decide between these and other possible explanations.

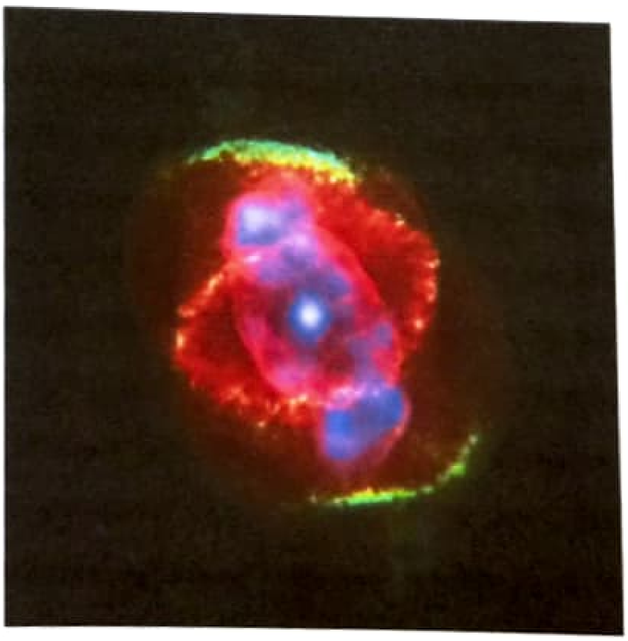


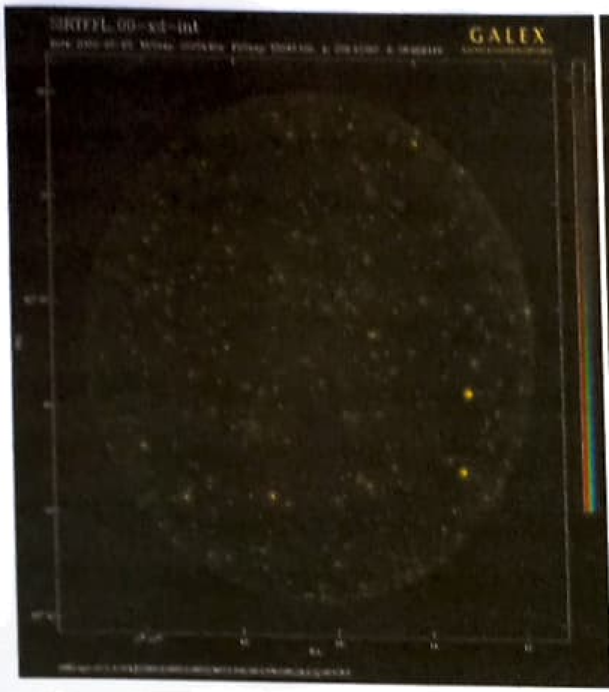
Fig.7 : Cat's Eye Nebula positioned at Right ascension 17h 58m 33.423s, Declination +66° 37′ 59.52″

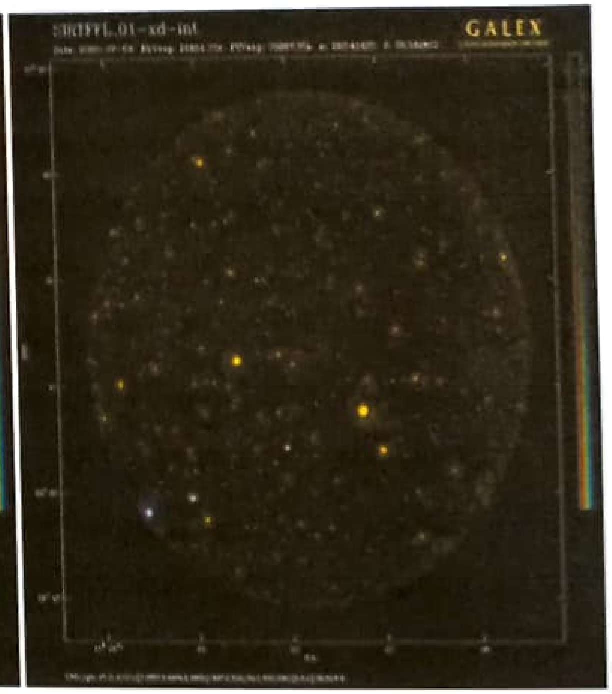
GALEX OBSERVATIONS IN CAT'S EYE NEBULA

Tile name	RA_cent	Dec_cent	NUV exp time	FUV exp time	NUV visits	FUV visits
SIRTFFL_00	259.11189	59.90714	55754.65	52049.5	43	39
SIRTFFL_01_css5394	260.47602	59.30012	1296	1296	1	1
SIRTFFL_04	256.98151	59.72117	3839.35	3839.35	3	3
SIRTFFL_06	257.58068	60.44664	28909.2	4925.45	23	10
SIRTFFL_08	262.60594	59.14585	41859.3	22560.75	29	20
SIRTFFL_09	257.20044	59.72179	15737.05	3208.95	12	9

GALEX UV SURVEYS

We took 5 GALEX UV Surveys of Cat's Eye Nebula for the current study. Each image has 1.2 degree field of view with 5 arc sec resolution. It takes about ten thousand of exposure time and belongs to deep imaging survey of GALEX. In its all images we can observe a brighter UV source which emit high energy blue light and is assumed as Quasar. The object is comes under the subclass of active galactic nuclei (AGNs), extremely luminous galactic cores where gas and dust falling into a supermassive black hole emit electromagnetic radiation.


SIRTFFL_00-xd-int
GALEX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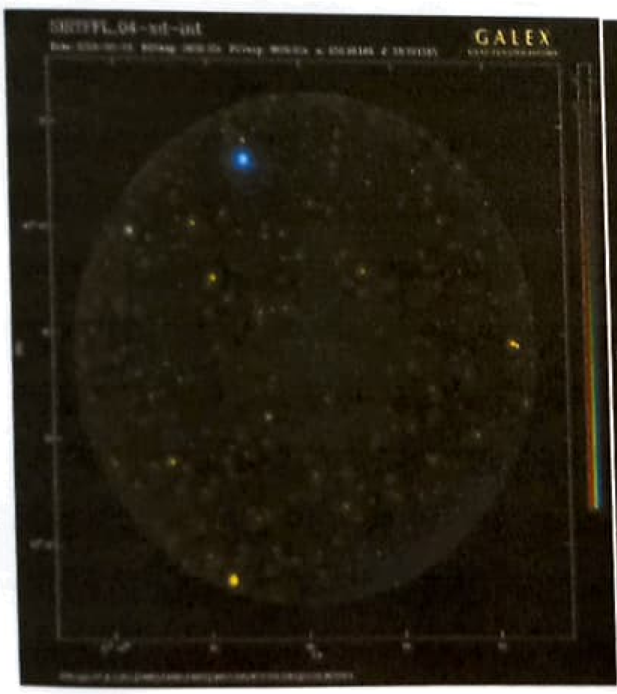
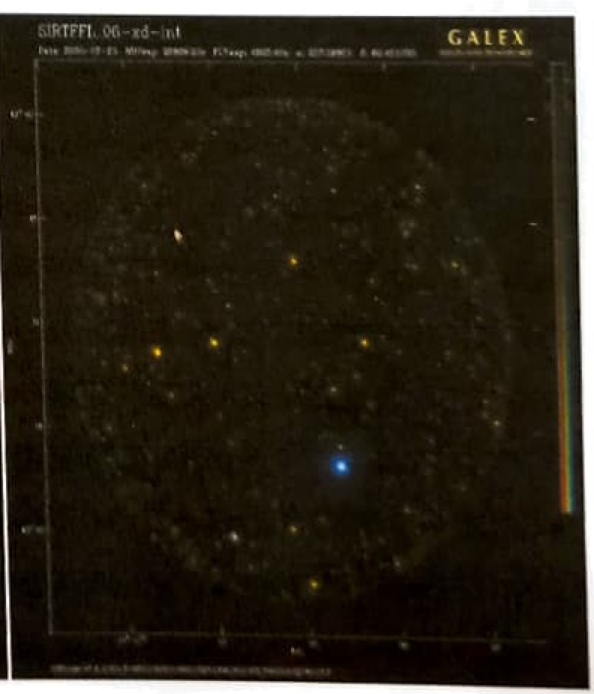
GALEX


SIRTFFL_04-xd-int
GALEX


SIRTFFL_06-xd-int
GALEX

CHAPTER IV

METHODOLOGY, RESULTS & DISCUSSIONS

METHODOLGY

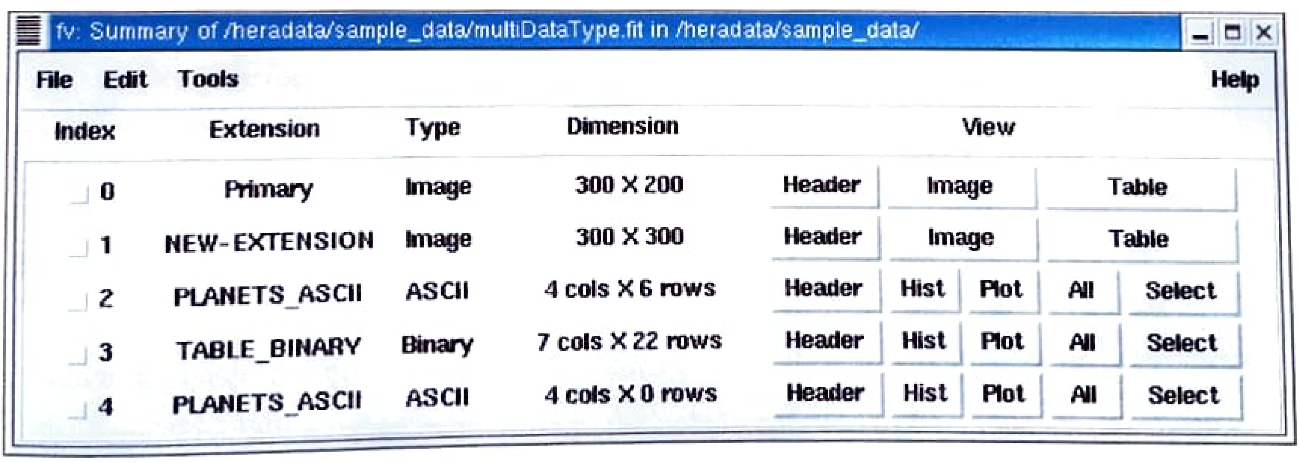
All Far and Near UV GALEX images and its source merged catalog files were downloaded from GALEX MAST archive. From the GALEX Far ultraviolet & Near Ultraviolet catalog mcat file, using FITS Viewer we had detected about 27,280 number of NUV sources & 26371 FUV Sources in 0.85 degree region of Cat's Eye Nebula.

FLEXIBLE IMAGE TRANSPORT SYSTEM: FITS VIEWER

In this study, we have used FITS viewer for extracting sources from the GALEX Catalog and the flux measurements were conducted based on the data given by FITS Viewer.

Details of FITS Viewer

Fits viewer[2] *(Fv)* is an easy to use graphical program for viewing and editing any FITS format image or table. *Fv* also provides dozens of powerful utility program which are available to manipulate local FITS file



- Do general image arithmetic using complex mathematical expressions
- Sort, merge, join, or filter rows of a table
- Compute statistics about images or table columns

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[2]https://heasarc.gsfc.nasa.gov/ftools/fv/

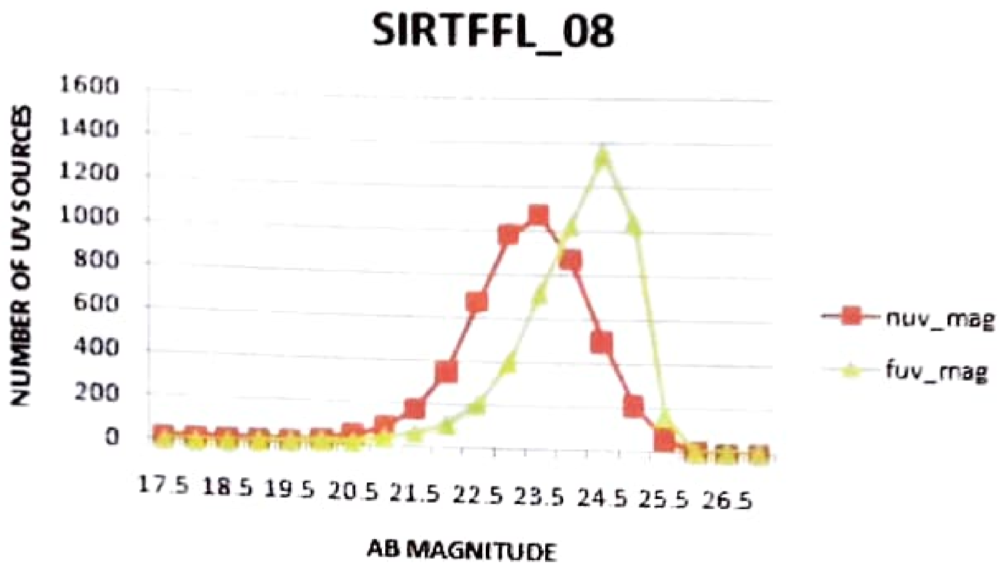
- Make ASCII listings of the contents of any image or table
- The programs run the same as if they were installed locally but they actually execute on the Hera servers.
- The input data files are transparently uploaded to the Hera servers where the program is executed, and any output FITS files and text output are transparently copied back to your machine after the program finishes.
- Hera tasks may be executed from the command line or using the special GUI built into *Fv*.

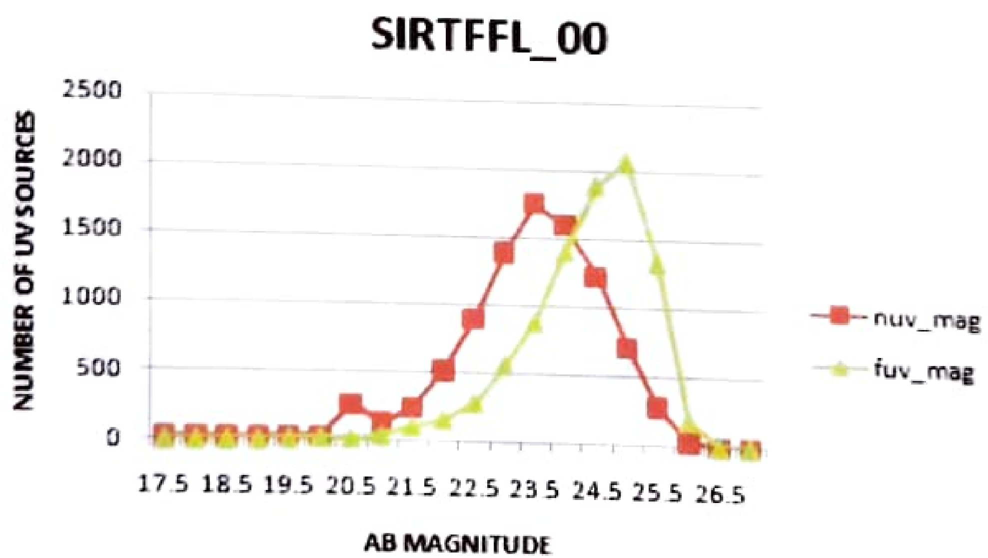
GALEX photometric catalog produced using SExtractor, extracted the flux details in CPS for the matching objects. The flux is then converted into AB magnitude as follows

- From mcat file:
  - Source positions in galactic coordinate system
  - nuv_flux (micro Jansky)
  - fuv flux (micro Jansky)
- 1 Jy = 10^{-23} erg/s/cm^2/Hz
- 1 micro Jansky = 10^{-29} erg/s/cm^2/Hz
- FUV: Flux [erg sec^{-1} cm^{-2} Å^{-1}] = 1.40 x 10^{-15} x CPS
- NUV: Flux [erg sec^{-1} cm^{-2} Å^{-1}] = 2.06 x 10^{-16} x CPS
  - FUV: $m_{AB} = -2.5 \times \log_{10}(CPS) + 18.82$
  - NUV: $m_{AB} = -2.5 \times \log_{10}(CPS) + 20.08$
  - FUV: $m_{AB} = -2.5 \times \log_{10}(Flux_{FUV} / 1.40 \times 10^{-15}$ erg sec^{-1} cm^{-2} Å^{-1}) + 18.82
  - NUV: $m_{AB} = -2.5 \times \log_{10}(Flux_{NUV} / 2.06 \times 10^{-16}$ erg sec^{-1} cm^{-2} Å^{-1}) + 20.08

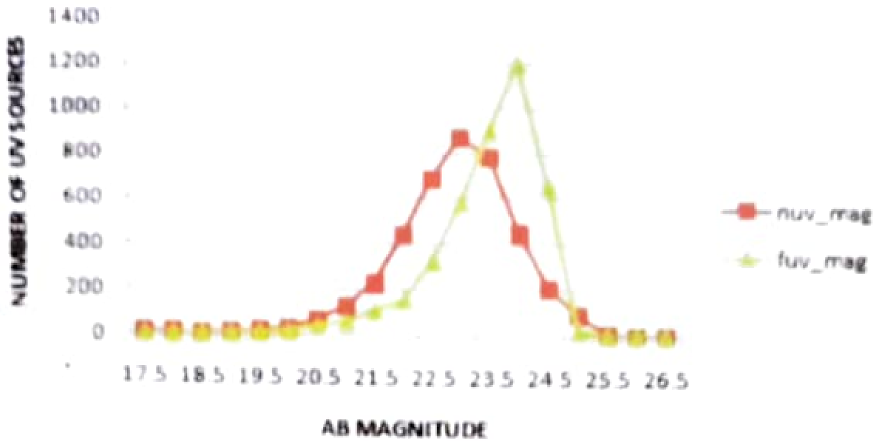
We have tabulated the number of sources and FUV & NUV fluxes in each tile of the Cat's Eye Nebula. The flux average estimation in the nebula is found to be ~539473 Micro jansky.

TILE NAME	NUV Sources	FUV Sources	NUV FLUX	FUV FLUX
SIRTFFL_08-xd-mcat_tl	5145	5189	107543.5908	4100.62948
SIRTFFL_00_css5394-xd-mcat_tlt	9170	9016	82699.20559	8122.08195
SIRTFFL_06-xd-mcat_tl	4076	4101	92811.27208	6728.720012
SIRTFFL_01-xd-mcat_tl	1729	1758	107254.9683	20213.07642
SIRTFFL_09-xd-mcat_tl	3233	3261	88266.52981	8526.206366
SIRTFFL_04-xd-mcat_tl	3927	3046	60898.26414	7115.41674

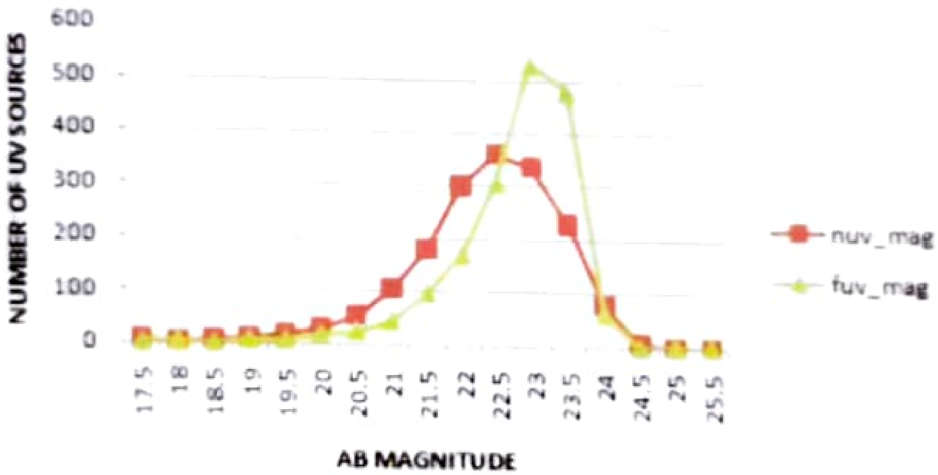

SIRTFFL_08
NUMBER OF UV SOURCES
1600
1400
1200
1000
800
600
400
200
0
17.5 18.5 19.5 20.5 21.5 22.5 23.5 24.5 25.5 26.5
AB MAGNITUDE
nuv_mag
fuv_mag

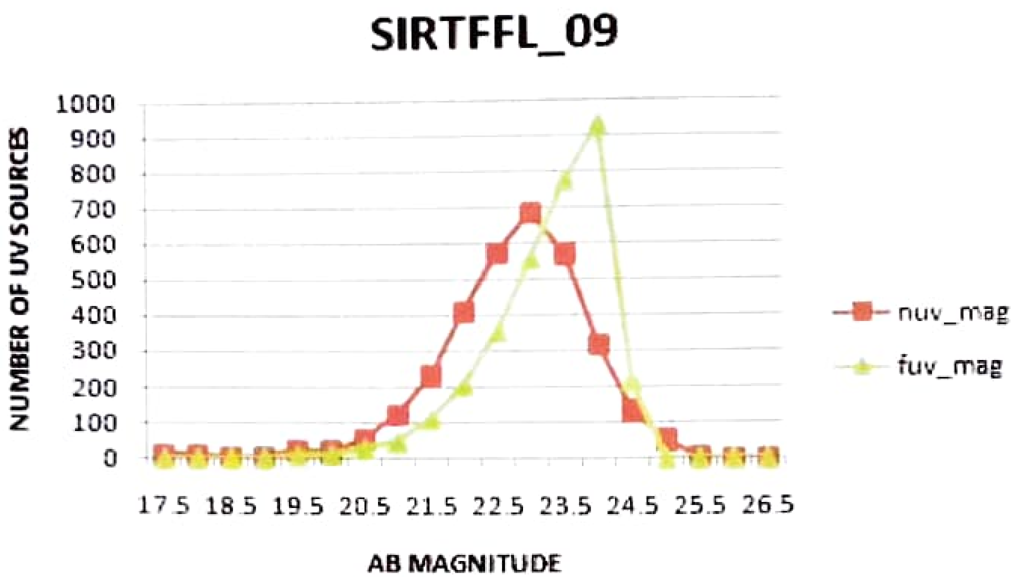

SIRTFFL_00
NUMBER OF UV SOURCES
2500
2000
1500
1000
500
0
17.5 18.5 19.5 20.5 21.5 22.5 23.5 24.5 25.5 26.5
AB MAGNITUDE
nuv_mag
fuv_mag

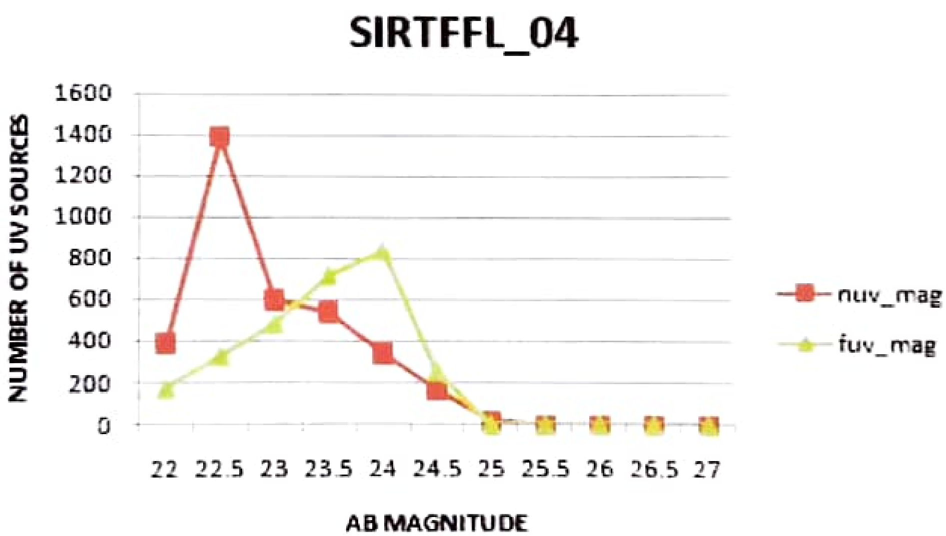
SIRTFFL_06



SIRTFFL_01_css5394







RESULTS & DISCUSSIONS

From the current study of number counts of GALEX Observations of Cat's Eye Nebula, there is Gaussian profile in two UV bands obtained for sources detected by GALEX except the tile SIRTFFL_04. The number of sources detected in NUV is 27280 and its total fluxes give rise to 539473 Micro Jansky. The sources in FUV are 2637 and 54807 Micro Jansky is obtained in this band. In SIRTFFL_04, the flux measurements may be varied due the over estimation of nearby GALEX sources, and is appeared in merged catalog data. But all others end with Gaussian profile and can be observed that there is dropout of sources after the magnitude 24 due to the limitations of GALEX. Our results are in good agreement with the previous studies (Bose et al 2015), up to the level of magnitude less than 22 because DIS observations of GALEX have several thousands of seconds exposure time and hence the data are 80% complete to NUV magnitude of 23 and FUV magnitude of 23.5, but the source confusion is significant in these observations. There is a drop out of number counts of galaxies occurs using GALEX at fainter side.

Reasons for finding drop out of sources at fainter side: Limitations of GALEX

It is mainly due to source confusion and magnitude compatibility with other background radiation. In the fainter side, errors are larger than brighter side indicates low sensitivity and resolution of GALEX. The high source density in deep images and the relatively large GALEX PSF results in a non eligible fraction of object blends in the pipeline catalogs, i.e. objects in close proximity remain unresolved. Another probable error could be due to the fact that the sources in the catalog may also be reported as systematically fainter due to the overestimation of the background level.

The standard GALEX pipeline provides a catalog of UV sources based on the detection. The flux measurements were done with SExtractor for each flux calibrated image. The width of GALEX point spread functions (PSF) are 4.5 and 5.4 arcsec in the FUV and NUV bands, respectively, thereby determine the resolution and hence restrict source identification (star/galaxy separation in deep fields)

FUTURE RELEVANCE OF THE STUDY

This analysis can be extended to larger area of UV observations. These investigations will narrow down to resolve the uncertainties in the number counts of UV sources. Our method of analysis of employing GALEX observations allows us to better evaluate the number counts of UV galaxies at much 11 higher spatial resolution than the previous results and to extend

UV observations of galaxies to fainter magnitudes. Modeling of UV radiation definitely requires more accurate number counts and hence, we evolved a more sensitive technique for estimation of the same. The source number counts in UV provides a reliable information of extragalactic background emission due to other galaxies beyond that our own. The study of number counts of sources can be used to measure the total luminosity of galaxies in a region, testing of galaxy models and an indirect way of Spectral Energy Distribution (SED) studies of galaxies. One could extend these studies comparing it with next generation of UV astronomical mission named Astrosat Sky surveys in UV band data, a multi wavelength astronomy mission on an IRS class satellite in a 650km near equatorial orbit.

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