

## Astronomy From Space

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Astronomy from the ground

What space can do for astronomers

Types of space mission

The Great Observatories

The Lunar Observatory

### 1) Astronomy from the Ground

At the beginning of this century we knew almost nothing about the galaxy we live in, and less still about the cosmos of galaxies beyond.

Astronomers have moved from using their eyes to examine starlight, to using hi-tech spectrographs and solid state photon detectors which can count photons one by one and measure each one's energy.

### 2) Space astronomy

The first space astronomy experiments, in the early 1960's, were very simple experiments. Explorer 11 in 1961 tried to measure the amount of gamma rays coming from the galaxy.

Astronauts on Gemini flights took UV film spectra of a few bright stars.

## Early Discoveries

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1962	Sounding rocket	discovers Sco X-1
1968	OAO-2	First space telescope
1970	Uhuru	accreting neutron stars, Cyg X-1
1977	HEAO-1	discovers hard x-rays from quasars
1978	IUE	Still going...
1978	Einstein	explores clusters of galaxies

## Space Astronomy Advantages

- Resolution:  
Atmosphere blurs spatial details
- Background:  
Radiation from atmosphere bright compared to sources
- Spectral range:  
Only a few 'windows' in atmosphere

## Glorious Technicolor

- Optical:  
Normal stars; warm gas heated by stars
- Infrared:  
Cool gas; stars hidden by dust; brown dwarfs
- Submillimeter:  
Cool gas with large molecules
- Radio:  
Plasma in magnetic fields; supernova remnants; bulk relativistic plasma jets
- Ultraviolet:  
Hot stars; stellar atmospheres; accretion disks; quasars
- X-ray:  
Neutron stars; black holes; ultra-hot gas
- Gamma rays:  
Neutron stars; Galactic center; what else? (stay tuned)

## Space Astronomy Timeline

- 1960-1975:  
Early experiments
- 1975-1990:  
Early observatories and sky surveys
- 1990-2010:  
The Great Observatories
- 2000-2020:  
Space Station Freedom attached payloads  
Great Observatories servicing
- 2020-2040:  
Lunar Observatory

## Today's Astronomy Spacecraft

Spacecraft	Launched	Owner	Notes
Voyager UVS	1977	NASA	UV spectrometer on VGR
IUE	1978	NASA/UK/ESA	Ultraviolet spectral observatory
Rontgen	1987	Glavkosmos	X-ray experiment, on Mir/Kvant
Ginga	1987	ISAS,Japan	X-ray observatory
Gamma Burst Network	1978-1989		Detectors on US and Sov probes
Hipparcos	1989	ESA	Positions and distances of stars
COBE	1989	NASA	Diffuse background studies

** Coming Soon **			
Spacecraft	Launched	Owner	Notes
HST	1990	NASA/ESA	Hubble Space Telescope
ASTRO	1990	NASA	10-day UV/X Shuttle mission
ROSAT	1990	FRG/NASA	X-ray sky survey
Gamma-1	1990	Glavk./CNES	Gamma ray expt.
GRO	1990	NASA	Gamma Ray Observatory
EUVE	1991	NASA	Extreme UV Explorer
Radioastron	1992	Glavkosmos	Space Radio VLBI
ASTRO-D	1993	ISAS	X-ray experiment
Spektr X- $\gamma$	1993	Glavkosmos	X-ray observatory
SWAS	1993	NASA	Submillimeter survey
XTE	1994	NASA	X-ray Timing Explorer
ISO	1994	ESA	Infrared Space Observatory
AXAF	1997	NASA	Adv X-ray Astrophysics Facility
FUSE	1998	NASA	Far UV spectroscopic Explorer
SIRTF	1998	NASA	Space IR Telescope Facility

## Issues in Astrophysics

- The Very Early Universe
  - Formation of matter and antimatter
  - Formation of space and time
- The Big Bang
  - Further study of relic fireball spectrum
  - Formation of structure from uniformity
- Galaxy Formation
  - When? (recent?)
  - Where? (large scales form first?)
  - How? (non-gravitational forces?)
- The Quasar Era
  - What powers quasars?
  - Why did they form?
  - Why are they less common now?
- Clusters of Galaxies
  - What is the dark matter?
  - Where does the cluster gas come from?



- Effects of galactic cannibalism
- Galaxies
  - What is the dark matter?
  - How do spiral density waves work?
  - Evolution of the chemical elements
  - Starbursts
- Stars and Gas
  - How do stars form?
  - Which stars make neutron stars and black holes?
  - How small can a star be?
  - What happens during and after a supernova?
  - What chemical reactions occur in cold gas clouds?
- Planets
  - How many stars have planets?
  - How many stars have habitable planets?
  - How common is life?
  - Now that we've torn down the Berlin Wall and freed Mandela, will the Galactic Federation let us join?