Astronomy From Space: History

- 1950-1969: Early tests, little science
- 1970-1977: Key pioneer missions, early science
- 1978-1989: 2nd generation, breakthrough science
- 1990-1993: 3rd generation and Great Observatories

Astronomy From Space: Advantages

- Spatial Resolution
- Low Background
- Wavelength coverage

Astronomy From Space: Wavebands

- Low Freq. Radio -
  - Only from space (Earth radio interference)
  - Study gas in our galaxy
  - Little known yet
- High Freq. Radio
  - Space gives access to long baselines
  - Early Space VLBI tests already
  - Study quasars, pulsars, star formation regions
- Submillimeter
  - Only from space or airplanes
  - Some windows available from high mountains
  - Study star formation regions
- Far Infrared
  - Only from space
  - Study galaxies and star formation regions
- Near Infrared
  - Easier from space
  - Study cool stars, quasars, primeval galaxies
- Optical
  - Space gives you high resolution
  - Study stars, galaxies

- Ultraviolet
  - Only from space
  - Study hot stars, quasars
- Soft X-ray
  - Only from space
  - Study supernova remnants, clusters of galaxies
- Hard X-ray
  - Only from space
  - Study quasars, binary neutron stars, black holes
- Gamma rays
  - Only from space
  - Study quasars, neutron stars

Some early missions

Aerobee AB3.352	1962	XR	Sco X-1 discovery
Rockets	1960s	UV, XR	
OAO-2	1968-1973	First UV observatory	Wisconsin, SAO
Vela 5	1969-1970s	XR monitor	Los Alamos
Uhuru	1970-1973	First XR survey	SAO
Apollo 16	1972	UV camera	NRL
Copernicus	1972-1980	UV observatory	Princeton
Apollo 17	1972	UV spectrometer	JHU?
SAS-2	1972-3	XR observatory	MIT
TD-1A	1972-4	UV survey	Europe
Ariel V	1974-1980	XR survey	Leicester, UCL
ANS	1974-1977	UV, XR	Groningen, Utrecht
ASTP	1975	EUV	UCB
HEAO 1	1977-1979	XR survey	NRL, GSFC, SAO, M
Hakucho	1979-1983	XR experiment	ISAS

Space astronomy comes of age

IUE	1978-1990s	UV observatory	GSFC
Einstein	1978-1981	XR observatory	SAO, MIT, CAL, GSFC
IRAS	1983	IR survey	JPL, UK, Neth.
Tenma	1983-1988	XR	ISAS
Exosat	1984-1986	XR observatory	Europe
Ginga	1987-1991	XR	ISAS
TTM	1987-1990s	XR	Birmingham, Utrecht
COBE	1989	Submm	GSFC, UCB, etc
Granat	1989-1990s	XR	Russia, France
EUVE	1992-?	EUV	UCB
HST	1990	UV	Great Observatory
CGRO	1991	Gamma	Great Observatory
AXAF-I	1998?	XR	Great Observatory
SIRTF	2000s??	IR	Great Observatory

Surveys and Observatories

- Sky Surveys
  - Map out all or part of sky in systematic way
  - Objective: Discover sources, make catalog
  - Usually PI mission
- Observatories
  - Point at specific parts of sky for short periods
  - Objective: Followup studies of known sources
  - Usually GO mission
- Diffuse Background
  - Like sky surveys but lower resolution
  - Objective: Study extended emission
  - Usually PI mission

PI and GO

- PI missions
  - Principal Investigator
  - The old-fashioned way
  - No peer review of time allocation
  - No public data rights
  - Tightly focussed science objectives
- GO missions
  - Guest Observer (also 'PI's)
  - The modern way
  - Peer-review TACs
  - Public archive after 1 year
  - General science objectives
  - Still some GTO time

IUE: a unique mission

- First GO mission
- Only mission with real time observing
- 15 years of operations
- 'Still going....'
- Tens of thousands of targets
- US and Euro shifts

Einstein: X-ray imaging

- Imaged clusters, supernova remnants
- main instruments: IPC and HRI
- Reentered in 1981
- Data analysis continues
- Final archive this year

ROSAT: X-ray survey

- Survey phase is PI, still not public
- Pointed phase is GO
- AO4 TAC meets March
- AO4 observations start June

Life story of a space observation

- AO is issued
- Study instrument specs
- Form GO team, prepare proposal; select targets, instrument config, exposure time
- Submit proposal
- TAC reviews proposal, allocates time and budget; cuts targets
- Mission Ops generates timeline, schedule
- Short term timeline loaded to spacecraft
- Observations executed automatically
- Data telemetered to Earth
- Mission Control does initial telemetry decoding, generates raw data product
- Spacecraft data center performs Level 1 processing to generate standard, calibrated data products
- Data products delivered to GO

- GO analyses data products, Level 2 analysis for science results
- Level 1 data products enter public archive
- Archival researchers obtain data products, for further science investigations

Major Discoveries from Space Astronomy

- Single stars - Chromospheres, Coronae; flare activity in low mass stars; protoplanetary disks; gamma ray bursts
- Binary stars - accretion onto compact companions, x-ray pulsars
- Stellar Black hole candidates
- Interstellar gas - star formation regions, composition of supernova remnants, the hole in the local ISM
- Galaxies - Infrared properties of galaxies, superstarbursts
- Quasars - Rapid X-ray variability, ultraviolet bump, beamed gamma ray emission, dust reprocessing
- Cosmology - Confirmation of blackbody radiation; tentative confirmation of anisotropies