

## The Multimission Archive at the Space Telescope Science Institute

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**Abstract.** We present an overview of the Multimission Archive at the Space Telescope Science Institute (MAST). The Hubble Data Archive has expanded to provide easy on-line access to non-HST data. MAST includes the following: IUE, EUVE, Copernicus, ORFEUS, ASTRO HUT, WUPPE, and UIT data, and VLA FIRST data. MAST is also the active archive site for the Far Ultraviolet Spectroscopic Explorer (FUSE), launched in June 1999, and provides access to the Digitized Sky Survey. We discuss the relevance of MAST for “data mining” studies, its literature links, and the features of the World Wide Web interface. We finally present our plans for expansion, which include the science public archive of the Sloan Digital Sky Survey, the new version of the Guide Star Catalog, and “on-the fly” creation of advanced data products.

### 1. Introduction to MAST

The Multimission Archive at the Space Telescope Science Institute (MAST) is NASA’s optical/UV science archive center. MAST, established in October 1997, builds upon the infrastructure developed for the Hubble Space Telescope archive but expands this service to support nine additional missions (see below).

Our data holdings include eight space-based missions, three of which (HST, EUVE, and FUSE) are currently active as of January 2001. We also provide archival services for two ground-based sky surveys: the Digitized Sky Survey and the VLA 20 cm radio survey known as FIRST. The combined MAST data volume exceeds 12 TB, making it one of the most significant astronomical collections available on-line today. All MAST data can be accessed at the MAST home page<sup>2</sup>.

The scientific value of MAST comes, in part, from the rich and varied astrophysical phenomena that dominate the optical/UV regions of the electromagnetic spectrum and from the convenient and user-friendly implementation of our World Wide Web (WWW) archive interface. The utility of the MAST

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<sup>2</sup><http://archive.stsci.edu/mast.html>

supported missions is demonstrated by the scientific literature publication rate of well over 1000 papers per year which make substantial use of these data.

## 2. The MAST Holdings

MAST includes the following missions:

**HST** Hubble Space Telescope (1100–25,000 Å), which contains over 250,000 exposures of  $\sim 30,000$  individual astronomical sources. Spectroscopic and imaging data are available from 7 widely-used instruments;

**IUE** International Ultraviolet Explorer (1200–3350 Å), which contains more than 104,000 spectral images of  $\sim 10,000$  individual astronomical sources;

**Copernicus** (OAO-3) far- (900–1560 Å) and near- (1650–3150 Å) ultraviolet spectra of 551 objects;

**EUVE** Extreme Ultraviolet Explorer (70–760 Å) spectroscopic observations of  $\sim 400$  sources, mostly galactic. EUVE was active through January 2001;

**FUSE** MAST is the active archive site for the Far Ultraviolet Spectroscopic Explorer, a NASA-supported mission successfully launched on June 24 1999, which is exploring the Universe with high resolution spectroscopy in the far UV (905–1190 Å) spectral region. FUSE is obtaining high resolution spectroscopy in the far-ultraviolet spectral region reaching 10,000 times fainter than Copernicus and superior resolution than HUT. FUSE is part of NASA's Origins Program under the auspices of NASA's Office of Space Science. MAST provides access to both proprietary and public FUSE data.

**ASTRO** includes three UV missions from the ASTRO 1 and 2 Space Shuttle missions:

- Hopkins Ultraviolet Telescope (HUT) (825–1850 Å), which includes about 500 ultraviolet spectra of more than 300 targets;
- Wisconsin Ultraviolet Photo-polarimeter Experiment (WUPPE) (1400–3200 Å), obtained simultaneous ultraviolet spectra and polarization measurements. It includes 400 observations of roughly 200 targets;
- Ultraviolet Imaging Telescope (UIT) (1200–3300 Å), which contains about 1,600 images of more than 200 targets;

**ORFEUS** Orbiting Retrievable Far and Extreme Ultraviolet Spectrometers, two UV missions from ORFEUS 1 and 2 Space Shuttle missions:

- Interstellar Medium Absorption Profile Spectrograph (IMAPS) (950–1150 Å), obtained high resolution ( $R=75,000$  for IMAPS-1) objective-grating echelle spectra. The IMAPS archive contains roughly 600 spectra of ten hot stars from the first Shuttle flight;
- Berkeley Extreme and Far-UV Spectrometer (BEFS) (400–1200 Å), which returned high-resolution ( $R = 5,000$ ) far UV spectra of 175 astrophysical objects from the two Shuttle flights. Extreme UV spectra (400–900 Å) were obtained for a subset of the targets.

Figure 1. The HST World Wide Web Interface.

**FIRST** Faint Images of the Radio Sky at Twenty-centimeters, a radio survey at 20 cm (1.4 GHz) of over 10,000 deg<sup>2</sup> down to a flux of 1 mJy. The radio images and the source catalog, currently  $\sim 720,000$  entries, are available;

**DSS** Digitized Sky Survey, digitized photographic plates from the Palomar and UK Schmidt telescopes;

**ROSAT** As a service to the optical/UV community, MAST provides also access to ROSAT (ROentgen SATellite) X-ray data. The ROSAT Master observations log (ROMASTER) at the High Energy Astrophysics Science Archive Research Center (HEASARC) is in fact accessible via an interface which is very similar to the other MAST interfaces.

### 3. The MAST Interface

The MAST listings are available via a simple WWW interface. A sample search page for HST data is shown in Figure 1. Similar interfaces are available for all MAST data. Archival data may be searched by name (resolved by SIMBAD or NED), position, object category, and observation specifics (date, instrument, filters, exposure time, etc.). Previews are available for most MAST missions, allowing users to have a “quick look” at the data before retrieving them.

### 3.1. MAST Cross-Correlations with Astronomical Catalogs

The potential use of the MAST archive is greatly increased by allowing users to search more than one mission/instrument at a time and cross-correlate the archive holdings with astronomical catalogs. Cross-correlations can be performed using the Hipparcos and Sky2000 stellar catalogs, an active galactic nuclei catalog, the Abell Galaxy Cluster catalog, and any user-supplied list of positions. MAST users can select a sample of astronomical sources based on a range of properties (e.g., redshift, magnitude, radio flux for active nuclei) and then look for the relevant entries in MAST. Work is in progress to expand this facility by using NASA's Astronomical Data Center (ADC) interface. This will allow cross-correlations to be made between MAST and any of the ADC catalogs and tables, opening up new possibilities for the exploitation of MAST data.

## 4. Literature Links

MAST data are linked to the scientific literature to allow users easy access to MAST-based papers directly from our interface. For most missions the WWW interface returns the papers based on a given dataset/proposal. Active links are provided to the Astrophysics Data System (ADS). We have worked with ADS to provide the complementary service, that is links between astronomical abstracts and MAST data previews, retrieval pages, and observation logs. Literature links to IUE, ASTRO, EUVE, BEFS, and Copernicus papers are already in place, while more than  $\sim 50\%$  of HST-based papers have been linked with their proposal ID. Work is on-going to complete the HST literature links and to provide the same service for the remaining MAST missions.

## 5. The Future of MAST

MAST will incorporate additional ultraviolet and optical data in the future, including those from the GALEX and CHIPS missions scheduled for launch in Fall 2001 and Spring 2002, respectively. Furthermore, MAST will host the science public archive of the Sloan Digital Sky Survey (SDSS) and the new version of the Guide Star Catalog (GSC-II). The SDSS will map in detail one-quarter of the entire sky, providing images for more than 100 million sources and redshifts for more than a million galaxies and quasars. GSC-II will include proper motion and color information, in addition to accurate coordinates, magnitudes and classification, for all objects in the sky down to at least 18th magnitude, an estimated 2 billion sources. MAST will further enhance the scientific value of its data holdings by archiving Mosaic Imager data from the National Optical Astronomy Observatories. To fully exploit the multiwavelength parameter space, which is being made available also by the many large surveys completed and under way, MAST will establish closer ties and coordination with other archive centers. MAST will work towards providing the community with science-ready products. This will include data characterization and catalogs of selected HST imaging data, thus enabling the identification of faint optical counterparts at various wavelengths, "on-the-fly" co-added spectra/images for objects with multiple exposures, and combined spectra spanning detector and mission boundaries.