The NASA/IPAC Extragalactic Database (NED) is a thematic online research facility designed to support scientists, educators, space missions and astronomical observatories in the planning, execution and publication of research on objects beyond our Milky Way galaxy. NED's ongoing mission is to provide the most comprehensive and easy-to-use multi-wavelength database of fundamental measurements for known (cataloged and published) objects beyond the Milky Way. NED is a portal into a systematic fusion of data linked from hundreds of sky surveys and thousands of research publications. The contents and services span the entire spectrum from gamma rays through radio frequencies, and they are continuously updated to reflect the current literature and releases of large-scale sky survey catalogs. NED has been on the Internet since 1990, growing in content and capabilities with the evolution of information technology. NED is operated by the Jet Propulsion Laboratory, California Institute of Technology, under contract with the National Aeronautics and Space Administration.

Inside you will find descriptions of NED’s primary features, samples of its rapidly growing contents, and illustrations of powerful new services to facilitate your research.

The NED team may be contacted at ned@ipac.caltech.edu

http://nedwww.ipac.caltech.edu
Primary NED Services

NED is the world's largest database of cross-identified extragalactic objects, containing approximately 10.1 million unique objects and 15.5 million multi-wavelength cross-IDs. Over 3 thousand catalogs and published lists covering the entire electromagnetic spectrum have had their objects cross-identified or associated and their data fused into the database for easy queries and retrieval.

Objects can be queried By Name (any alias) using the NED name interpreter; Near Name or Near Position (cone search); By Reference (Refcode), and By Author. By Parameter (Advanced All-Sky) queries utilize joint constraints on Redshift, Sky Area, Object Types, Survey Names, and Flux density/magnitude to construct galaxy samples. The complexities of SQL are hidden from the user by the NED software and interface.

Available data include Positions, Redshifts, Morphological and Spectral Classifications, Photometry, Images, Spectra (New!), Diameters, Cross-IDs, Associations, Reference Abstracts and detailed Notes. Measurement uncertainties are included where available, and all information is cited and linked to the on-line literature via ADS.

Other tools include a Coordinate Calculator that performs conversions and precession and displays line-of-sight Galactic extinction estimates; a Velocity Calculator that converts between Heliocentric, Local Group, Galactic Standard of Rest, and 3K Microwave Background; and an XY-Offset to RA/Dec converter.

Seamless Connectivity

Globally distributed services are linked by object names and positions in NED. See page 5 for details.

Knowledgebase for Extragalactic Astronomy & Cosmology

See page 10 for details.

Links to On-line Literature

Data in NED are cited and linked to the on-line journals via ADS. Abstracts may be queried individually from specific data entries, or in groups By Object, By Author, or full Text Search.

Links into NED: Photometry, Images, Diameters, Positions, Redshifts, Spectra, Notes.

Links to External Archives

http://nedwww.ipac.caltech.edu
Spectral Energy Distributions

NED provides Spectral Energy Distributions (SEDs) covering the whole electromagnetic spectrum. Fluxes and their uncertainties (or upper limits), gathered from large survey catalogs and from the literature, are displayed in various user-requested standardized units. Aperture information and ties to the originating literature are provided for every data point. Great care goes into understanding and documenting the details of the measurements (metadata), and the data are provided to users in original published units (magnitudes, Janskys, etc.), and uniformly converted to various standard units for display and SED plotting.

Multi-wavelength Images and Visualization

NED provides a unique collection of images which are interconnected, documented, and available for queries and immediate download. The science-grade images in FITS format are highly processed data submitted by researchers around the world after publication (in plot form) in the peer-reviewed literature. Galaxy images from 2MASS, DSS, and other major surveys are also available. In 2003 we introduced the capability to search the NED image archive by sky areal coverage. Sky visualization and interactivity between images and database entries are provided via Aladin (CDS) and OASIS (IRSA). Clicking on the the Aladin icon launches the Java applet with the corresponding image loaded along with marker overlays for objects in NED and separate planes for the USNO (optical), 2MASS (near-infrared) and NVSS (radio) catalogs.
One of the most frequently requested NED enhancements has arrived! When redshifts are available, data for galaxies now include corrected velocities, Hubble flow distances and scales, and cosmology-corrected quantities.

**Derived Values** based on the object's redshift (if known) and position:

- **Calculated and Corrected Velocities**, with errors:
  1. \( V \) (Heliocentric) in km/s with its error (if known) and source, calculated from \( V = zc \). No relativistic correction is applied to these apparent redshifts (see John Huchra's discussion of extragalactic redshifts for more information).
  2. \( V \) (Galactocentric GSR) in km/s calculated as in RC3.
  3. \( V \) (Local Group) in km/s based on the formulation by Karachentsev and Makarov (AJ 111, 794, 1996).
  5. \( V \) (Virgo Infall only) based on the local velocity field model given in Mould et al. (ApJ 359, 786, 2000) using only the term for the influence of the Virgo Cluster.
  6. \( V \) (Local Infall) based on the local velocity field model given in Mould et al. (ApJ 359, 786, 2000) using the terms for the influence of the Great Attractor and the Shapley Supercluster, as well as the Virgo Cluster (we thank Jim Condon for his code for this model), on which we have based ours. Note that the declinations of the Great Attractor and the Shapley Supercluster given in Table A1 of Mould et al are negative, and that the minus signs in their Equation A2 should all be positive).

The errors in the model parameters for each correction are added in quadrature to the error in the galaxy's redshift as follows: 4% of the Local Group correction, 6% of the 3K CMB correction, 7% of the cosmology-corrected velocities field correction. No derived distance is given if the corrected velocity is negative.

- **Hubble Flow Distances and Distance Moduli**, with their errors, calculated from the apparent corrected velocities assuming \( H_0 = 73 \pm 5 \) km/s/Mpc.
- **Scale at the Hubble Flow Distances**, in parsec/arcsec, kiloparsec/arcsec, kiloparsec/arcmin, and megaparsec/degree.
- Several quantities derived from the redshift corrected to the reference frame defined by the 3K background, and further corrected for a cosmological model with \( H_0 = 73 \) km/s/Mpc, \( \Omega_{\text{matter}} = 0.27 \), and \( \Omega_{\text{vacuum}} = 0.73 \). We thank Dr. Chris Burns (OCIW) for the code behind these calculations. Further explanation of the calculated quantities is available through Ned Wright's Cosmology Calculator web site, and through Albert Cappi's CosmoTools web site.

### Sample output for IRAS F10214+4724 at heliocentric \( z = 2.28560 \)

<table>
<thead>
<tr>
<th>Derived Values</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Calculated and Corrected Velocities</strong></td>
<td></td>
</tr>
<tr>
<td>( V ) (Heliocentric)</td>
<td>685204 +/- 9 km/s</td>
</tr>
<tr>
<td>( V ) (Galactocentric GSR)</td>
<td>685224 +/- 9 km/s</td>
</tr>
<tr>
<td>( V ) (Local Group)</td>
<td>685234 +/- 9 km/s</td>
</tr>
<tr>
<td>( V ) (3K CMB)</td>
<td>685416 +/- 17 km/s</td>
</tr>
<tr>
<td>( V ) (Virgo Infall only)</td>
<td>685360 +/- 14 km/s</td>
</tr>
<tr>
<td>( V ) (Local Infall)</td>
<td>685317 +/- 14 km/s</td>
</tr>
<tr>
<td><strong>Hubble Flow Distance and Distance Moduli</strong> (where ( H = 73 +/- 5 ) km/sec/Mpc)</td>
<td></td>
</tr>
<tr>
<td>Scale (Galactocentric GSR)</td>
<td>45506 pc/arcsec = 45.506 kpc/arcsec = 2700.50 kpc/arcmin = 163.03 Mpc/degree</td>
</tr>
<tr>
<td>Scale (Local Group)</td>
<td>45506 pc/arcsec = 45.506 kpc/arcsec = 2700.50 kpc/arcmin = 163.03 Mpc/degree</td>
</tr>
<tr>
<td>Scale (3K CMB)</td>
<td>45820 pc/arcsec = 45.820 kpc/arcsec = 2711.23 kpc/arcmin = 163.87 Mpc/degree</td>
</tr>
<tr>
<td>Scale (Virgo Infall only)</td>
<td>45918 pc/arcsec = 45.918 kpc/arcsec = 2711.08 kpc/arcmin = 163.85 Mpc/degree</td>
</tr>
<tr>
<td>Scale (Local Infall)</td>
<td>45914 pc/arcsec = 45.914 kpc/arcsec = 2700.85 kpc/arcmin = 163.05 Mpc/degree</td>
</tr>
</tbody>
</table>

### Cosmology-Corrected Quantities

- **Distance** to 73 km/sec/Mpc, \( \Omega_{\text{matter}} = 0.27 \), \( \Omega_{\text{vacuum}} = 0.73 \)
- **Redshift** corrected to the Reference Frame defined by the 3K Microwave Background Radiation:
  - Luminosity Distance | 10059 Mpc | (\( z = 2.28 \)) |
  - Angular-Distance Distance | 1672 Mpc | (\( z = 2.28 \)) |
  - Co-moving Radial Distance | 3085 Mpc | (\( z = 2.28 \)) |
  - Co-moving Tangential Dist. | 3085 Mpc | (\( z = 2.28 \)) |
  - Co-moving Volume | 695 Gpc^3 |
  - Light Travel-Time | 10.467 Gyr |
  - Age of Redshift | 2.852 Gyr |
  - Age of Universe | 13.309 Gyr |

### Surface Brightness Flattening:

- Fixed Density per Unit Area | 0.000377 |
- Magnitude per Unit Area | 26.167 mag
NED provides seamless connectivity to globally distributed services, serving as a thematic Virtual Observatory portal.

The External Archives and Services section of NED query result pages contains simple 1-click access to distributed images, catalog data, and observation log entries.

Distributed services are also highly connected to NED.

Observatory control systems and various Internet sites query NED for a variety of services, including accessing positions, redshifts and basic data on galaxies, resolving names, receiving images, etc.

http://nedwww.ipac.caltech.edu
Spectral Energy Distribution Data Tables

New! NED VO Capabilities & Tabular Output

Plot the spatial distribution of an Allsky (By Parameter) query with constraints on redshift, flux density (mag), object types, survey membership and cross-IDs

VOTable output options

VOTable and simple ASCII output options

Plain ASCII ➞ Easy import into Excel, etc.

VOPlot, Specview, etc.

Plain ASCII ➞ Interactive visualization with VOPlot, Specview, etc.

17 orders of magnitude of frequency coverage:

3.80E+07 (38 MHz radio)
to1.48E+24  EGRET 4-10 GeV gamma rays

Aitoff plot with VOTable

January 2008

http://nedwww.ipac.caltech.edu

http://nedwww.ipac.caltech.edu
NED users (2003 user survey, Advisory Committee, others) asked for a way to filter the growing literature based on data content and specific extragalactic topics.

The technical literature on text search is filled with debates on the merits of free-text search versus use of a controlled vocabulary (e.g., http://en.wikipedia.org/wiki/Controlled_vocabulary).

The latter often results in more precise results due to normalization of terminology (synonyms, etc.).

Examples: “starburst” = “H II” (context: nuclear spectral type); “ultraviolet” = “UV”.

NED is assigning and displaying two types of journal article keywords:

- Data Content Keywords (all papers)
- Topical Keywords: currently pre-2000 only via ARIBIB (http://www.ari.uni-heidelberg.de/aribib/)

Both keyword sets are displayed and utilized in new (optional) filters on NED literature searches based on object names and author names.

**Data Content Keywords**

NED captures the data content of papers. Using semi-automated procedures, we can therefore assign keywords to a small but important subset of categories: Galaxy Classifications, Diameters, Components, Images, Photometry, Kinematics, Detailed Object Notes, Positions, and Spectroscopy (redshift).

Such information often cannot be inferred from titles and abstracts alone, but requires knowledge of the content of tables, figures, etc.

**Topical Keywords**


The ARIBIB activity (humans classifying paper content) ended in 2000.

Detailed classification of article content cannot be extracted from titles and abstracts alone, but requires analysis of the paper content.
Primary design goals are to provide:

1. A repository for spectra corresponding to rendered plots in journal articles, as submitted to NED by authors; also supports other available spectral archives
2. Preview plots for each spectrum
3. Preservation of the original data format submitted by authors and archive curators
4. Value-added standardized (MKS) units and a uniform VOTable data format
5. ASCII and VOTable download options
6. A query service to enable users to locate spectra by object name, journal article (refcode), passband, spectral lines, and combinations thereof
7. Quick-look visualization and analysis, facilitating fusion and comparison of spectra
8. VO Interoperability
Database Contents

As of the January 2008 Release:

- 15.5 million multi-wavelength source cross-identifications
- 10.1 million unique extragalactic objects
- 38.8 million photometric measurements spanning gamma-rays through radio wavelengths
- (with uncertainties) and dynamic SEDs
- 6.2 million detailed size measurements with uncertainties
- 4.5 million object pointers to 67 thousand journal articles
- 1.4 million redshifts
- 2.3 million FITS images, maps and links with previews
- 65 thousand detailed notes from catalogs and other publications
- 44 thousand journal article abstracts
- 52 thousand spectra

Updates: New Objects in NED

- 2,597,657 detailed r-band diameter data points for the 659,000+ SDSS DR5 objects as noted above.
- 18,009 galaxies from the 2MASS Flat Galaxy Catalog in 2004BSAO…57….5M, Mitronova et al: The 2MASS-selected Flat Galaxy Catalog
- 12,555 JVAS/CLASS radio sources from 2007MNRAS.376..371J, Jackson et al: A survey of polarization in the JVAS/CLASS flat-spectrum radio source surveys - I. The data and catalogue production
- 5,884 SDSS QSOs with z > 3 from 2007AJ…133.2222S, Shen et al: Clustering of High-Redshift (z >= 2.9) Quasars from the Sloan Digital Sky Survey

Other NED Features

- A key NED activity is cross-identification and association of millions of entries in multi-wavelength survey catalogs and publications using a combination of computer software that utilizes positional uncertainty information to compute probability measures, followed by close inspection to resolve complex cases that cannot be fully automated.
- Galaxy attributes and data relationships are revised and augmented constantly to keep up with new survey data and knowledge appearing in the literature.
- Updates to the public database occur approximately every three months after periods of data entry, quality assurance, and testing using an internal development and test database.

http://nedwww.ipac.caltech.edu
A Knowledgebase for Extragalactic Astronomy and Cosmology

- Available at http://nedwww.ipac.caltech.edu/level5/
- Hyperlinked review articles (e.g., ARA&A) and documents of current and lasting interest to cosmologists and extragalactic astronomers
- Contents include a glossary of terms, essays, recent research articles, detailed monographs and extensive reviews (where copyrights allow).
- Within each article
  - Cited extragalactic objects are cross-linked to NED Basic Data frames
  - Citations are hyperlinked to ADS
  - Tabular data, images and graphs are linked to and from relevant essays and review articles
- Total number of articles to date 647

NEW ADDITIONS

- MOLECULES IN GALAXIES - Alain Omont (2007)
- A FAINT NEW MILKY WAY SATELLITE IN BOOTES - V. Belokurov et al. (2006)
- STELLAR POPULATIONS IN THE LOCAL GROUP OF GALAXIES - Eva K. Grebel (2005)
- NEAR-FIELD COSMOLOGY WITH LOCAL GROUP DWARF SPHEROIDALS - Eva K. Grebel (2005)
- BRIGHTEST CLUSTER MEMBERS - James M. Schombert (1990)
- THE EXTRAGALACTIC GAMMA RAY BACKGROUND - Charles D. Dermer (2007)
- SKY SURVEYS AND DEEP FIELDS OF GROUND-BASED AND SPACE TELESCOPES - V.P. Reshetnikov (2005)

The Level 5 Glossary and Lexicon of Astronomical Terms received the Griffith Observatory Star Award in July 2003 for excellence in promoting astronomy to the public through the World Wide Web.