Astronomical Data Analysis Software and Systems VI
ASP Conference Series, Vol. 125, 1997
Gareth Hunt and H. E. Payne, eds.

Integrating the HST Guide Star Catalog into the NASA/IPAC Extragalactic Database: Initial Results

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Abstract. We report initial results of cross-identification of extragalactic objects from the NASA/IPAC database and Guide Star Catalog (GSC). A distribution of galaxies on the sky is discussed as a tool for estimating the probability for a given GSC object to be of a particular type.

1. Introduction

The GSC (with 20 million objects, making it the biggest and most complete sky survey to date) provides accurate object positions. The NASA/IPAC Extragalactic Database (NED)[1] contains positions, extensive data, and 1,023,000 cross-identifications for over 592,000 extragalactic objects (galaxies, quasars, and radio sources). NED currently represents the unique merger of some 40 major catalogs and many shorter listings. Catalogs and lists are being integrated into NED on a continuing basis, following a detailed cross-identification process.

Benefits of NED-GSC cross-identification are obvious for both sides. For many astronomical studies the GSC is unique; but its full potential is still out of reach. At present, the GSC lacks even rudimentary cross-identifications with other astronomical catalogs, and consequently little is known about either the nature of the objects themselves or their relationship to other data already cataloged and independently available in machine-readable form. NED can make use of the accurate positions found in the GSC.

2. General Cross-identification Strategy

The following general strategy is applicable to all kinds of object lists, not only those from NED. By "source list" we will refer to any external list of objects of a homogeneous nature (e.g., NED galaxies, NED IR sources, etc.)

Stage 1: a small sampling of objects from the source list is cross-identified manually, using our GUIDARES (Malkov & Smirnov 1995) and ZGSC software (Smirnov & Malkov 1997) applications. Cross-identification is attempted with both GSC objects, and in the case of multiple entry GSC objects, with individual entries. **Results:** an initial ruleset for automatic cross-identification; confidence estimates.

[1] http://www.ipac.caltech.edu/ned/ned.html

Stage 2 (iterative): the full source list is cross-identified automatically, using the current ruleset. **Results:** Confidently identified objects can be analyzed for hidden dependencies between GSC and external list data. This can yield additional rules and criteria, at which point Stage 2 is repeated. Questionable cases can be analyzed manually.

Final cross-identification results: (*i*) List of unambiguously cross-identified objects, (*ii*) list of ambiguous (one source object, several GSC objects) cross-identifications, (*iii*) questionable cases—for manual analysis, and (*iv*) unidentified objects from the source list.

These results will be provided to the maintainers of the source list or database in question.

3. Initial Results

Here we present results of **Stage 1** cross-identification process for NED galaxies and NED IR sources. Note that the NED list of IR sources does not contain IR sources with an optical counterpart, e.g., galaxies. The 23% below are, therefore, IR sources *with an identified GSC optical counterpart not listed in NED.*

	confidently identified	poorly identified	not identified
galaxies	84%	4%	12%
IR sources	23%	4%	73%

Confident cross-identifications provide an exciting possibility. If a sufficient number of source objects is confidently identified, we can expect to derive specific rulesets that describe the "mean" GSC representation of objects of the same type. These rulesets, coupled with object probability maps (see below), can be applied to the whole GSC in an automatic scan for unlisted objects of the same type. For example, the excellent cross-identification results for NED galaxies suggest that the GSC can yield a wealth of previously unknown galaxies. This is also suggested by two of our preliminary findings:

1. GSC photometry for diffuse objects is, typically, 3–5 magnitudes brighter than actual values. The GSC's formal limiting magnitude of 15^m–16^m is, as far as galaxies are concerned, closer to 18^m–19^m.

2. At least 5% of GSC "stars" are in reality galaxies, nebulae, multiples, etc.

We also give preliminary results on cross-identification of some other types of NED objects with the GSC:

Quasi-stellar objects: too faint to be included in the GSC.

Gamma sources: NED positional errors are too high. It is only possible to indicate the brightest GSC star in the vicinity of the source.

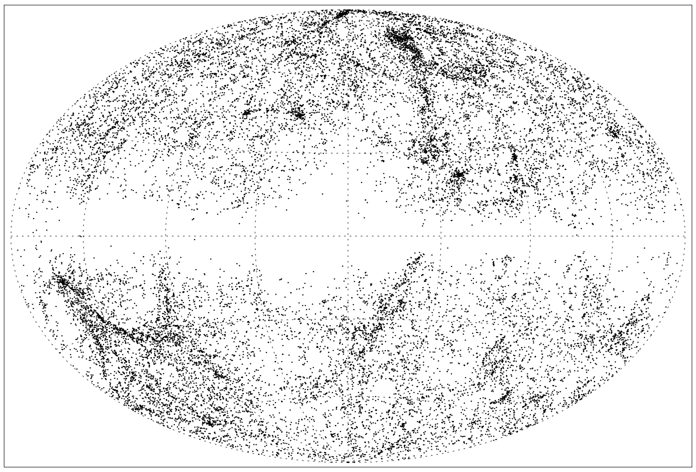

Figure 1. Third Reference Catalogue of Galaxies (galactic coordinates, Aitoff projection).

Clusters of galaxies: Results are very poor.

Planetary nebulae: confidently identified, but no "automatic" discovery is possible, as their GSC counterparts are undistinguishable from stars.

Radio sources: not identifiable at all.

Note again that the NED lists of gamma or radio sources does not contain those sources with a known optical counterpart.

4. Object Probability Maps

Object probability maps (OPMs) are based on the mean density of objects of a particular type at given coordinates and magnitude. OPMs can be used to estimate the probability for a given object to be of a particular type. This provides additional information on the nature of GSC objects (consider, e.g., galaxies' zone of avoidance, or the lack of asteroids at high elliptic latitudes).

To estimate the probability of a given object being a galaxy, we have to know both the stellar distribution and distribution of galaxies. The density of objects is approximated by the function $N = N(m, b)$, where N is the mean number of objects per square degree brighter than m at galactic latitude b (dependence on longitude is assumed to be negligible).

For the stellar distribution, an old but still unsurpassed Seares & Joyner (1928) paper was selected. In this paper, m is given in the international photographic scale. The paper employs the old galactic coordinate system; however, the difference is not significant for our purposes.

To create a distribution of galaxies we had to evaluate available catalogs according to the following criteria: completeness in coordinates, magnitudes, sizes, etc.; large number of objects. After detailed analysis, the Third Reference Catalogue of Bright Galaxies, RC3 (de Vaucouleurs et al. 1991) was selected. It

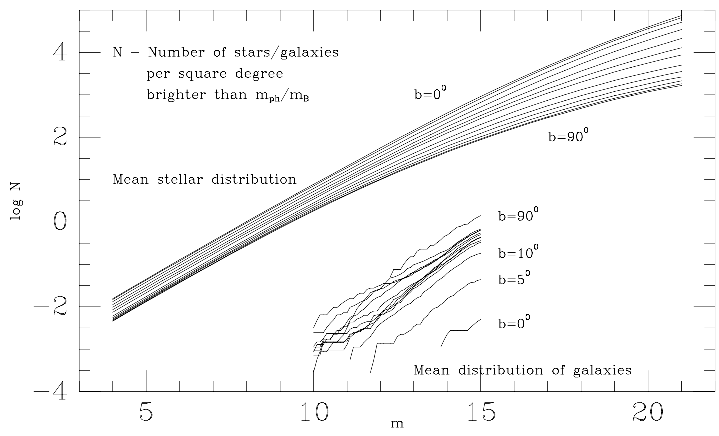

Figure 2. Stellar distribution and distribution of galaxies.

contains 23,011 objects (see Figure 1) and is complete for galaxies having apparent diameters larger than 1′ at the D_{25} isophotal level and total B magnitudes B_T brighter than about 15.5^m, with a redshift not in excess of $15{,}000\,\mathrm{km\,s^{-1}}$. The RC3 employs the new galactic system. The catalog has shortcomings: it is inhomogeneous, and not every object is supplied with a magnitude.

The RC3 contains 7 different magnitude bands. We selected m_B, because: (*i*) it yields good correlation with GSC magnitudes, (*ii*) it is more representative in RC3 than other magnitudes, and (*iii*) it is close to the system used in the stellar distribution.

Only 75.6% of RC3 objects have m_B magnitudes. We used six other parameters that were well-correlated (better than 0.59) with m_B, to estimate m_B where it was absent. This produced a total of 22,907 (99.5% of RC3) usable objects. Distributions of galaxies and stars are shown on Figure 2. This should allow us to create the required galaxy distribution by fitting the density of RC3 objects with an analytical formula.

Acknowledgments. Drs. Marion Schmitz (Caltech) and Conrad Sturch (STScI) are gratefully acknowledged for valuable advice and constant help in our work. This presentation was made possible by financial support from the Logovaz Conference Travel Program. OM is grateful to the Russian Foundation for Fundamental Researches for grant No. 16304.

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