

Baltic Astronomy, vol. 6, 81 – 88, 1997.

THE NEW NASA SKYMAP SPACECRAFT ACQUISITION AND TRACKING CATALOG

Wayne H. Warren Jr.

*Hughes STX Corporation, Laboratory for Astronomy and Solar Physics, NASA
Goddard Space Flight Center, Greenbelt, Maryland 20771*

Alvin C. Miller and Joanne R. Myers

*Computer Sciences Corporation, Flight Dynamics Division, NASA Goddard
Space Flight Center, Greenbelt, Maryland 20771*

David A. Tracewell

*Flight Dynamics Division, NASA Goddard Space Flight Center, Greenbelt,
Maryland 20771*

Received May 24, 1996

ABSTRACT. A preliminary version of the new edition (4.0a) of the SKYMAP spacecraft acquisition and guidance/tracking star catalog has recently been completed at the Goddard Space Flight Center (GSFC). The catalog has been completely redone from the ground up using the most up-to-date sources for astrometric, photometric, spectroscopic, double/multiple-, and variable-star data. Unnecessary data included in the previous version of SKYMAP have been omitted from the new catalog and the format has been redesigned for general astronomical use. The new catalog presently contains 299,523 entries, but that is expected to change during subsequent work. A very detailed and careful quality assurance (QA) effort is now in progress and, if that can be completed using the methods desired, the final catalog should be a high-quality comprehensive source of stellar data for stars to about magnitude 9.

Key Words: catalogs

1. INTRODUCTION

The SKYMAP star catalog has been used by NASA for many years as its spacecraft acquisition and tracking catalog. The original catalog was assembled about 20 years ago (Gottlieb 1978) and had undergone several revisions, but no major update. As such, the previous version was based on astrometry from the SAO Catalog (SAO Staff 1966), photometry and spectroscopy dating from the 1970s, and various information (e.g., cross identifications) taken from machine-readable star catalogs from that era, which often contained errors. In fact, through most of the previous version's lifetime, changes had been the result of error detection and correction. The above situation, combined with the fact that many unnecessary and invalidly derived data existed in the old SKYMAP, and that near-infrared photometric data had to be added for CCD star-tracker applications, resulted in our decision to completely rebuild SKYMAP.

Thus, we essentially started from scratch, designed a preliminary data content and format based on the previous SKYMAP and on those changes needed to upgrade the catalog. All previously derived data, except an estimate of V magnitude, which is needed for star-tracker operation and for estimating red magnitudes, were omitted from the new catalog. When observed values of MK spectral type, radial velocity, and certain other data are not available, their fields are simply left blank. Other information previously included, such as stellar distances, has been eliminated, since it is neither reliable nor needed for catalog applications. This paper briefly describes the objectives of the SKYMAP enhancement project, the procedures used for updating the catalog, and the types of information to be treated.

2. OBJECTIVES OF THE ENHANCEMENT

The principal objective of the catalog enhancement project was to ensure that the data most critical to SKYMAP spacecraft applications are as reliable as possible. Therefore, highest priority was given to positional, photometric, and multiple-star data, since these are the most important toward avoiding spacecraft acquisition failures. Other data will be analyzed and checked as time permits.

A second objective of the SKYMAP work was to prepare a new star catalog of high enough quality to be useful as a tool for astronomical applications and research. SKYMAP is unique in that no other existing catalog compilation of stellar data provides such a wide variety of basic information for so many individual objects.

3. DATA CONTENT OF SKYMAP

The SKYMAP catalog contains a wide variety of useful data, including cross identifications in many of the major star catalogs, astrometric and positional data, radial velocities, trigonometric parallaxes, geocentric inertial (GCI) unit vectors, and galactic coordinates. Broad-band photoelectric data, including R and I, are reported when available, while V values are estimated from a rather sophisticated procedure when photoelectric data don't exist. Both two-dimensional (MK) and the older one-dimensional (HD, etc.) spectral types are given, and extensive data are provided for multiple and variable stars.

3.1 Astrometric Data

Positional and proper-motion data in the new SKYMAP are expected to be the most reliable initially, since several highly accurate sources were available for the inclusion of J2000.0 astrometric information. Astrometric data were added to the catalog in hierarchical order (see Warren and Hoffleit 1993) starting with the SAO Catalog and extending up through the FK5 (Fricke et al. 1988, 1991), although the great majority of positions and proper motions come from the PPM (Röser and Bastian 1989; Bastian and Röser 1993) and the ACRS (Corbin and Urban 1990) catalogs.

3.2 Photometric Data

Approximately 11 percent of SKYMAP 4.0a stars have photoelectrically measured magnitudes and colors in the broad-band UBV system. While V magnitudes (called V) for the remaining stars were "derived" from older photovisual/photographic data in combination with spectral types, the derived values are considerably less accurate than the photoelectric data. However, there are several other photometric systems (e.g., $uvby\beta$ and Geneva) for which photoelectric measurements produce broad-band V magnitudes and in which many stars have been measured that have no UBV data. Machine-readable catalogs of measurements in these systems exist and will be used to supplement the UBV data. Incorporation of V magnitudes from these systems will produce a significantly larger fraction of SKYMAP stars with photoelectrically determined V data, and it is also possible to transform certain colors to the UBV system.

3.3 Data for Double and Multiple Stars

Double and multiple stars are the most difficult objects to deal with in catalog work, but they are also among the most critical for spacecraft

acquisition and tracking applications, since accurate information is required for the sensors to make correct identifications.

While the previous version of SKYMAP (3.7) merged entries for many bright double and multiple stars, our specification for the new version required that separate entries be inserted for all stars whose separations exceed 1 second of arc. This requirement was based on the increased resolution of the new CCD detector systems being utilized on current and future missions. The most comprehensive source for multiple-star data, the Washington Catalog of Visual Double Stars (WDS) (Worley and Douglass 1995) was used as the primary source catalog, with older Aitken (ADS) (Aitken 1932) designations being replaced by WDS identifiers. All data relevant to spacecraft acquisition and tracking applications (magnitude differences of components, separations, and position angles) were transferred to SKYMAP.

The difficulty with this procedure lies in the fact that the WDS is structured as a double-star catalog and correctly contains entries for pairs of stars, while SKYMAP contains data for individual components of multiple-star systems. Thus, an entry for a pair of stars in the WDS includes an identifier for only one component of a system whose components often have different identifiers in SKYMAP. It is, therefore, not possible to identify each SKYMAP component in the WDS by computer and correctly assign component designations and double-star data.

Although for the initial build of the new SKYMAP multiple-star data were inserted from the WDS entirely by computer (time constraints precluded manual examination), data for many components are missing and component letter designations were either not at all or incorrectly assigned. These problems must be fixed during quality assurance of the final version.

We also plan to examine the new Catalog of Components of Double and Multiple Stars (CCDM, Dommanget and Nys 1994) recently released for dissemination from the data centers. This catalog, which became available after the completion of the initial version of SKYMAP, is a superset of one prepared for the Hipparcos mission; it contains separate entries for individual components of multiple systems. Although based on an earlier version of the WDS, the CCDM can be used to identify and label specific components in SKYMAP.

3.4 Data for Variable Stars

The identification of known variable stars and information about

amplitudes and periods of variability also constitute critical data for successful acquisition and tracking applications. SKYMAP has been updated with information from the General Catalogue of Variable Stars, 4th edition (GCVS4) (Kholopov et al. 1985 - 8) and the New Catalogue of Suspected Variable Stars (NSV) (Kukarkin et al. 1982), plus questionable variability remarks from the BSC5. This information must be checked carefully to ensure correct identifications of the variable stars themselves and of variable components of multiple-star systems. For example, it has already been discovered that in certain case, variability has been misassigned to the bright components of double stars when it is really the faint components (not SKYMAP stars) that are variable.

Additional work includes the identification of SKYMAP variable stars among several lists of newly discovered variables that have appeared since the GCVS4 catalog was compiled. New data will be added to SKYMAP for an estimated several hundred recently discovered variables

4. THE CURRENT PRELIMINARY VERSION OF SKYMAP

A preliminary version of the new SKYMAP catalog has been prepared. It contains 299 523 stars. This version is presently undergoing revisions to change the data content slightly, to improve the format, and to analyze and correct existing errors. It will also be thoroughly quality assured and new data that have recently become available will be incorporated.

Figs. 1 through 3 show a few of the photometric relations for the preliminary catalog. Thorough quality assurance of the photoelectric data and reprocessing of many of the photovisual and photographic data are expected to improve these relations considerably.

5. SUMMARY

A new version of the NASA satellite acquisition and tracking star catalog (SKYMAP) has been prepared in preliminary form. The catalog includes J2000.0 astrometric data, plus photometric and spectroscopic data for almost 300 000 stars. The final version of the new catalog will be an accurate compilation that should be useful for a wide variety of astronomical applications.

ACKNOWLEDGMENTS

We thank a number of colleagues who have provided us with data and/or given us access to their data prior to publication. These persons include T. E.

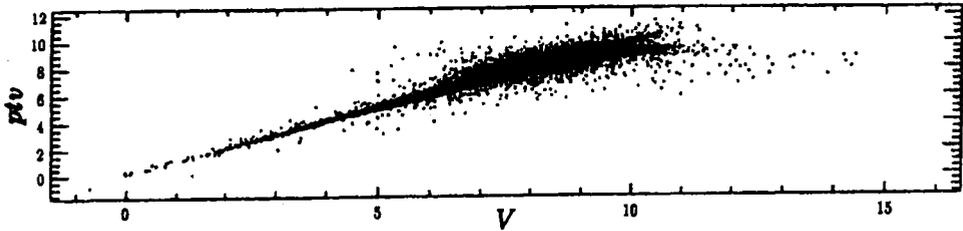


Fig. 1. A comparison of photoelectrically determined V magnitudes with older photovisual data from catalogs such as the HD and SAO. Since photoelectric UVB observations are not available for 80 percent of SKYMAP stars, pTv and spectral data must be used to derive approximate values of V. Thus, it is important that pTv data be reasonably uniform and accurate. The figure shows 58 127 stars having both V and pTv data. The scatter is quite small down to about magnitude 7 and even reasonable beyond, but there are quite a few stars well away from the line that clearly have bad data. These are almost certainly from the erroneous inclusion of faint companions to in place of or in addition to a brighter star.

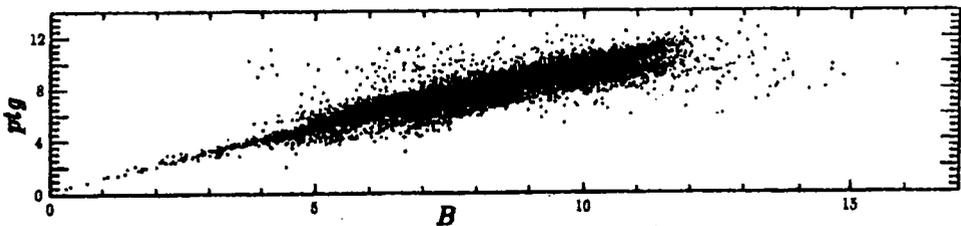


Fig. 2. Although the scatter in photographic magnitude is much greater, it is apparent that the same problems exist, undoubtedly for many of the same stars. However, there are many more points well to the left of the band and we suspect that a rather large number of photovisual magnitudes are incorrectly located in the field.

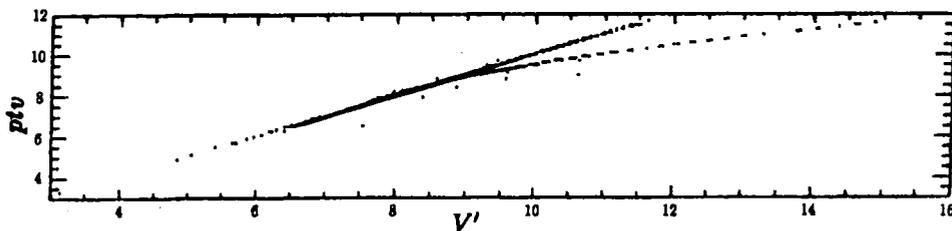


Fig. 3. Here we plot derived V magnitudes (called V') against ptv for 207 447 stars. Although the data correlate well (V' is derived using ptv in most cases), two prominent branches develop at magnitude 9 and extend all the way to the faint limit. This phenomenon is unexplained at present.

Corbin, J. C. Mermilliod, E. H. Olsen, B. A. Skiff, W. F. van Altena, C. E. Worley and G. G. Douglass.

REFERENCES

- Aitken R. G. 1932, *New General Catalogue of Double Stars within 120° of the North Pole*, Carnegie Institution of Washington Publ. No. 417, Carnegie Institution of Washington, Washington, DC
- Bastian U., Röser S. (in collaboration with Yagudin, L. I., Nesterov V. V.) 1993, *Catalogue of Positions and Proper Motions, South*, Astronomisches Rechen-Institut, Heidelberg
- Corbin T. E., Urban S. E. 1990, *Astrographic Catalog Reference Stars (ACRS) catalog*, US Naval Observatory, Washington, DC
- Dommanget J., Nys O. 1994, *Comm. Obs. R. Belgique, Ser. A, No. 115*
- Fricke W., Schwan H., Lederle T. (in collaboration with Bastian U., Bien R., Burkhardt G., du Mont B., Hering R., Jährling R., Jahreiss H., Röser S., Schwerdtfeger H. M., Walter H.G.) 1988, *Fifth Fundamental Catalogue (FK5), Part I. The Basic Fundamental Stars*, Veröff. Astron. Rechen-Institut Heidelberg, No. 32
- Fricke W., Schwan H., Corbin T. E. (in collaboration with Bastian U., Bien R., Cole C., Jackson R., Jährling R., Jahreiss H., Lederle T., and Röser S.) 1991, *Fifth Fundamental Catalogue (FK5), Part II. The FK5 Extension, New Fundamental Stars*, Veröff. Astron. Rechen-Institut Heidelberg No. 33
- Gottlieb D. M. 1978, *ApJS*, 38, 287

- Kholopov P. N., Samus N. N., Frolov M. S., Goranskij V. P., Gorynya N. A., Kireeva N. N., Kukarkina N. P., Kurochkin N. E., Medvedeva G. I., Perova N. B., Shugarov S. Yu. 1985, *General Catalogue of Variable Stars*, 4th edition, Nauka Publishing House, Moscow
- Kukarkin B. V., Kholopov P. N., Artiukhina N. M., Fedorovich V. P., Frolov M. S., Goranskij V. P., Gorynya N. A., Karitskaya E. A., Kireeva N. N., Kukarkina N. P., Kurochkin N. E., Medvedeva G. I. Perova N. B., Ponomareva G. A., Samus N. N. Shugarov S. Yu. 1982, *New Catalogue of Suspected Variable Stars*, Nauka Publishing House, Moscow
- Röser S., Bastian U. 1991, *Catalogue of Positions and Proper Motions North*, Astronomisches Rechen-Institut, Heidelberg
- Smithsonian Astrophysical Observatory Staff 1966, *Star Catalog: Positions and Proper Motions of 258,997 Stars for the Epoch and Equinox of 1950.0*, Publ. of the Smithsonian Institution of Washington, DC No.4652, Smithsonian Institution, Washington, DC
- Warren Jr. W. H., Hoffleit D. 1993, in *Workshop on Databases for Galactic Structure*, A. G. D. Philip, B. Hauck and A. R. Uppgren, eds., L. Davis Press, Schenectady, p. 217
- Worley C. D., Douglass G. G. 1995, *Washington Catalog of Visual Double Stars*, US Naval Observatory, Washington, DC