The Steward Observatory Asteroid Relational Database

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Abstract

The Steward Observatory Asteroid Relational Database (SOARD) has been created as a flexible tool for undertaking studies of asteroid populations and sub-populations, to probe the biases intrinsic to asteroid databases, to ascertain the completeness of data pertaining to specific problems, to aid in the development of observational programs, and to develop pedagogical materials. To date SOARD has compiled an extensive list of data available on asteroids and made it accessible through a single menu-driven database program.

Users may obtain tailored lists of asteroid properties for any subset of asteroids or output files which are suitable for plotting spectral data on individual asteroids. A browse capability allows the user to explore the contents of any data file. SOARD offers, also, an asteroid bibliography containing about 13,000 references. The program has online help as well as user and programmer documentation manuals. SOARD continues to provide data to fulfill requests by members of the astronomical community and will continue to grow as data is added to the database and new features are added to the program.

Introduction

Asteroids are characterized by their diversity. We study them using a wide variety of remote sensing techniques in an attempt to determine their composition and physical properties, and relate this information to processes effecting asteroids and other solar system bodies over the age of the solar system. Observations are obtained through groundbased telescopes and radar, and spacecraft such as the Infrared Astronomical Satellite (IRAS). These observations are dedicated surveys or focussed on individual objects of particular interest. SOARD incorporates the data obtained from these various observations into a single database.

In order to evaluate and exert some quality control over the data, it is critical to be able to trace each datum to its origin. In addressing scientific issues it is important also to have a knowledge of and access to the existing literature on the subject. SOARD contains an asteroid bibliography containing about 12,000 references, from the 19th century into the year 1992.

In addition to being objects of scientific investigation, asteroids are potential resources to be utilized in support of the expansion of humans into the solar system. The most accessible of these are the Near Earth Asteroids (NEA's) whose motions around the Sun bring them within reach of low-energy transfer orbits from the Earth. Until recently, the information available on the NEA's has been relatively limited, but with increased rates of discovery and greater numbers of observational programs focussing on these objects, this information is expected to grow rapidly. Since NEA's derive from the main asteroid belt (though some may be extinct comets), knowledge of their source populations provides additional insight into the nature and physical properties of NEA's.

SOARD's goal is to incorporate ALL published asteroid data into one generally accessible database for use in research and in expanding our general and specific understanding of asteroid populations.

SOARD is a menu-driven asteroid database management system which utilizes dBase IV software in a fashion transparent to the user. It allows four basic system outputs at this time: (1) files of designations of asteroids satisfying range criteria for parameters or functions of parameters, (2) subsets of database parameters for subsets of asteroids, (3) files of multiband photometry or spectroscopy for individual asteroids (for plotting), and (4) files of bibliographic references satisfying users' search criteria. Any data file may be examined using a SOARD browse capability.

Table 1. SOARD Data Sets

Asteroids II

- Proper Orbital Elements
- Taxonomic Classifications
- Family Designations
- Pole Orientations
- Magnitudes, UBV Colors, Albedos, and Diameters

IRAS

- Radiometric Diameters and Albedos
- Individual IRAS Observations
- Polarimetry file
- Lightcurve file
- UBV Observations
- 8-Color Spectroscopy
- 24 Color Spectroscopy

Miscellaneous

- 52-Color Spectroscopy (J. Bell)
- Osculating Orbital Elements (E. Bowell)
- Preliminary Designations and Discovery Circumstances (MPC)
- Photometric Parameters (MPC)
- Proper Elements (Milani and Knezevic)
- Radar Observations (S. Ostro et. al.)

Asteroid Bibliography (C. Cunningham)

Table 2. Existing Data Sets for Future Addition

- CCD Spectroscopy (L. McFadden, F. Vilas)
- Near-IR Spectra (Lebofsky, Bus, et. al.)

SOARD Data

Table 1 lists the individual data sets which are currently online and accessible through SOARD. It combines ground based observations which were published in ASTEROIDS II, radiometric data collected by IRAS, ancillary IRAS data sets of groundbased polarimetry, lightcurve, and spectroscopic observations, Jeff Bell's 52-color near-IR survey, osculating orbital elements for 19,945 asteroids, discovery information and photometric parameters published through the Minor Planet Circulars (MPC), ground based radar observations, and 12,742 literature references. As data is incorporated into SOARD, it receives a reference to its source in the literature which is listed in the bibliography file. This provides online information on the origin of the data and allows maximum understanding of data quality. Data evaluation is critical to its use in an engineering context.

SOARD Reference Capability

SOARD has acquired and incorporated Clifford Cunningham's asteroid bibliographic reference file. Cooperation led to suggestions for expansion of his original file. Fields which were added include a keyword field and a field which lists the asteroids to which the reference pertains. This expansion which has been implemented already for the major journals and for recent publications is currently a part of SOARD. Full implementation for all citations would require further man hours. Cliff Cunningham was very helpful in agreeing to alter his file format to make it more compatible with SOARD requirements. Although he is marketing his database as a salable product, he has generously given permission to distribute it as part of SOARD to the test sites. In its implementation in SOARD, a user can search the reference file by author, title, date, publication, keyword, asteroid numbered designation, some subset of authors or words in a title, or any combination of these parameters. We regard this utility as a powerful addition to SOARD. SERC will need to contract with Clifford Cunningham and develop a licensing agreement if they wish to continue to distribute his product.

Updating the Database

Ongoing observations and research promise a continually growing body of data which should be added to SOARD. Current monthly updates to SOARD include data available through literature searches, data sent by individual observers, and data obtained from the Minor Planet Circulars (MPC). Maintenance of this ongoing update program of the data sets already incorporated into SOARD is the most efficient way of preserving the work which has brought the database to its current level of usefulness. SOARD should eventually expand to include the data sets listed in Table 2. Some of the data, such as CCD spectroscopy of certain asteroids, has been published. Some data is collected and needs to be reduced and published. Data addition procedures have been fully

documented in the SOARD programmer's manual so they can be undertaken at any point by a person with basic computer knowledge.

Expanding SOARD

Additional programming will expand the features available through SOARD. A fourth main menu item will allow the user to concatenate functions of asteroid parameters. If a file contains orbital elements such as semi-major axis and eccentricity, the user may calculate the perihelion distance as an output parameter of specific interest. This feature will minimize data which must be distributed with the system while allowing the user maximum choice for customized output of asteroid parameters.

All SOARD programs have been fully documented and logged in the programmer's manual so as to facilitate future expansion of the SOARD interface.

User Interface and Testbed Activities

User's and programmer's manuals have been completed and offer more comprehensive guidance than is desirable with the on line help capability previously built into SOARD. SOARD testbed activities include the following sites: the California Space Institute in La Jolla, California (Dr. Lucy-Ann MacFadden); the Institute for Astronomy in Honolulu, Hawaii (Dr. David Tholen); the Lunar and Planetary Laboratory at the University of Arizona in Tucson, Arizona (Dr. Larry Lebofsky and Ellen Howell), and the Park School in Brookline, Massachusetts (Dr. Linda French). A transportable execution version of the relational database has been distributed to these sites to test without the assistance of prior tutoring but with the help of online documentation only. Already they have provided substantial input into the overall user friendliness of the system and made suggestions for improving the SOARD environment. With the addition of a test site at the Park School the educational applications of SOARD at the pre- collegiate level are being explored. Input from testsites has been and will continue to be incorporated into the SOARD planning and programming process.

Community Support

We respond to all moderate requests from the community and have provided data in support of observing, research, and teaching programs. For instance, for the last few years SOARD has been asked for assistance and has supplied pedagogical materials for the University of Arizona's Steward Observatory run Adult, Beginning, and Advanced Teen Space Camps.