The Terre Haute Astronomical Object List (THAOL) Program: A Public Relations and Teaching Resource

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Abstract

This paper is a discussion of the features of a computer program which lists all of the astronomical objects available for observation by any given instrument under any given sky conditions, at any time and date, for any spot on the earth.

Observations from a small observatory located in a large city are hindered by variable atmospheric conditions more than by small apertures. Such an observatory is best suited for public relations and education, but research depends upon the determination in advance which objects are most easily studied from such a location. A list of observable objects can be compiled if numerical parameters describing normal atmospheric conditions and instrumental limits are known. Measurements for the Indiana State University Observatory indicate that on good nights the limiting magnitude of the 6-inch refractor is 12 for objects more than 45° above the horizon, but objects of second magnitude cannot be seen below about 20° altitude above the horizon. On nights of poor visibility, this second magnitude limit reaches the zenith, and although the sky is not cloudy, only the moon and bright planets can be seen with the naked eye.

With observational limits well defined, a list of visible objects until recently has been too detailed an undertaking to prepare repeatedly. The repetitive nature of the calculations required suggests the use of high-speed data processing equipment. The above observations, standard lists of astronomical objects, and unlimited run time on the IBM 360 computer at Indiana State University have been combined to produce the Terre Haute Astronomical Object List, THAOL for short. The computer scans the catalog of objects, computes their altitudes for the desired location and date, and prints out lists of those objects which can be seen with the prevailing atmospheric conditions and available instrumentation.

The object list is divided into six sub-lists: double stars, open and globular clusters, nebulae and galaxies are taken from lists in the *Observer's Handbook* (1). We intend to supplement these lists with the *New General Catalog* (2) when detailed lists of faint objects are required. The list of moving objects must be re-punched for each time period; in particular, the Moon's location must be changed every hour.

Most of the program converts non-decimal numerals to decimal numbers, and prints the corrected numerals in a useful format. A block diagram of the program (Fig. 1) illustrates the two kinds of input cards: parameter cards and object lists. The parameters of position on the earth, date and time, observational limits, and the name of

the institution or place of observation are included on one card, which is entered before each deck of object cards. From these parameters, local sidereal time is computed from formulas familiar to the beginning astronomy student:

1) Local Sun Time = Local Standard Time—[(Local Longitude—Standard Time Meridian) × (1 Hour/15°)][1]
2) Sidereal Time = Local Sun Time + [2 hours × (current month—9)] + [4 min. × (date—23)]

The azimuth and altitude of each object can be obtained by:

3) Hour Angle = Sidereal Time—Right Ascension
4) Zenith Distance = arc-cos [sin(latitude) × sin(declination)] + [cos(latitude) × cos(declination) × cos(hour angle)]
5) Altitude = 90°—Zenith Distance
6) $\text{Azimuth} = 180° + \text{arc-sin}\left[\frac{\sin(\text{hour angle}) \times \cos(\text{declination})}{\sin(\text{zenith distance})}\right]$

For the computed altitude, a minimum observable magnitude is computed, and is compared with the visual magnitude of the object. If an object is too faint for its altitude, it is omitted from the list. If an object is bright enough to observe, it is placed on one of two lists, depending on whether it is east or west of the meridian. Two lists are essential when an equatorial telescope mounting is in use, as the telescope must be repositioned to cross the meridian. A third list, which consists of those planets above the horizon but not well placed for observation is also collected. When a complete set of objects has been processed, lists of the visible objects in the set are printed before the next parameter card is read.

Although only right ascension, declination and magnitude are used in computation, each object card contains alternate names, size of object, orbital details, distance from the earth, light time, and other important features. For some objects the information is packed tightly on the 80 character card, but is separated into readable units on the printout, which is 130 characters wide. Changes in the list can be made at the telescope, and new information can be added to the object list before it is run through the computer again. When running smoothly, the 6 object lists are scanned and printed in less than 4 min.

Besides observational work, this program can be useful in the laboratory. Lists calculated for differing sky conditions at one location can be compared, and the optimum telescope size for any site can be determined with a minimum of site-testing. Lists assuming the same atmospheric conditions can be run for several latitudes and compared, providing a graphic display of how latitude affects the local horizon. For public viewing nights, it is reassuring to have a complete list of objects that are observable without difficulty.

With the success of the THAOL program, we have been encouraged to devise other computer-produced observing aids. Our ephemeris of sunrise, sunset, beginning and end of evening and morning twilight, moonrise and moonset has been expanded to include a brief astro-

[1] For a first approximation, the equation of time can be left out.

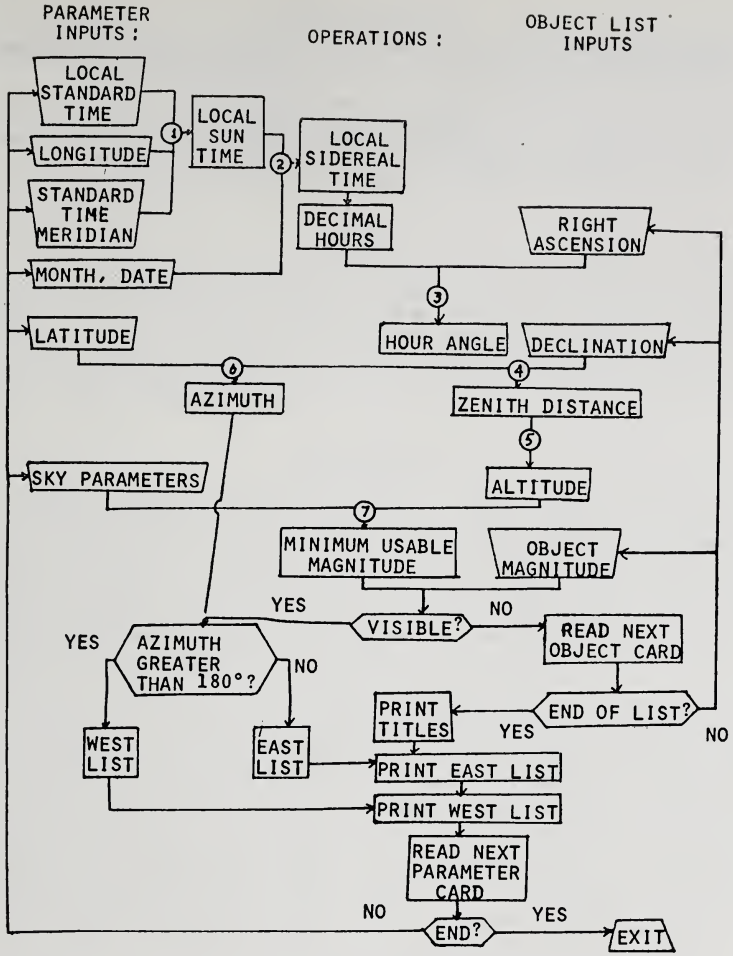

FIGURE 1. *The Terre Haute astronomical object list program block diagram.*

nomical calendar. The ephemeris for observations of Jupiter and Mars in the *American Ephemeris and Nautical Almanac* (3) has been used to compute hourly positions of Jupiter's Red Spot, central Equatorial Zone, fifth satellite, and the meridian of Mars. These simple programs are of great help to our observers, and are available on request. For those of you without computing facilities available, the Indiana State University computing center will run an occasional list if the necessary papameters are supplied: latitude, longitude, name and local standard time meridian of the observatory or site, lowest altitude at which second magnitude starts are visible, altitude above which objects are visible to the limiting magnitude of the available instruments, limiting magnitude of those instruments, and dates and times for which the information is required.

Literature Cited

1. Royal Astronomical Society of Canada, The. 1972. The observer's handbook for 1973. Toronto, Can. 105 p.

2. 1974. The new general catalogue of non-stellar objects. Sky Publ. Corp.

3. U.S. Naval Observatory. 1971. The American ephemeris and nautical almanac for 1973. Washington, D.C. 584 p.