

## *The Astronomy of Position*

**A**STRONOMY, like all natural sciences, necessarily depends upon a foundation of facts of observation. Two types of astronomical observations are required: (1) systematic continued observations of the apparent positions and motions of the principal celestial bodies as seen projected on the celestial sphere, for the purpose of deriving their actual arrangement and motions in space and determining the structure and fundamental dynamical laws of the planetary system and the stellar universe and (2) observations of the individual celestial bodies with the telescope, spectroscope, and other instruments, for the purpose of determining their physical nature and obtaining detailed information about the phenomena and physical conditions on each one.

The data obtained by observations of the first type form the essential foundation and framework of the entire science of astronomy. They are the direct foundation of theoretical and gravitational astronomy; they are essential to the solution of the fundamental problems of galactic structure and stellar dynamics, and many problems of astrophysics; and they are the immediate basis of the applications of astronomy to navigation, surveying, and the accurate determination of time. The principles upon which these observations and their interpretation are based, and the theory of their applications to practical problems, constitute the subject of Spherical Astronomy, to which this treatise is devoted.

In the technical astronomical sense, an *observation* is more than merely watching the occurrence of a phenomenon or looking at an object through a telescope: it is the accurate determination and careful recording of definite data of a particular kind for a specific purpose—either to serve some immediate practical need, or to obtain information that will contribute to the solution of problems still unsolved. The regular work of astronomical observatories is devoted to the observations which at the time are useful for these purposes. The collation and coordination of the accumulated observations that have been taken for a particular purpose, and the interpretation of the results, are commonly referred to as the *discussion* of these observations.

Of special importance are sustained programs of continued determinations of the apparent positions in right ascension and declination of the Sun, Moon, planets, and principal stars, independently of any former deter-

minations, and with the highest possible accuracy, extending in an unbroken series over long intervals of time. At observatories where positional astronomy is a regular part of the work, the practice is to maintain a continuous series of daily meridian observations for this purpose. These observations are necessary for accurately establishing the coordinate system of right ascension and declination on the celestial sphere, and for constructing a precise system of time measurement and determining the values of the principal astronomical constants. The reference system of position and time established by means of these observations, and the basic constants, planetary tables, and fundamental star catalogs derived from them, are indispensable throughout astronomy and in its practical applications.

Long continuous series of homogeneous observations at a number of different observatories are needed to determine accurately the motions of the Sun, Moon, and planets over extended periods of time, and to obtain the repeated measurements of the positions of the stars that are necessary for determining their proper motions. The continued maintenance of these programs of observations is required in order to obtain progressively improved values of the fundamental astronomical constants and of the elements of the planetary system, and to determine increasingly accurate positions and proper motions of the stars. The calculation of ephemerides of the stars and other celestial bodies, required for astronomical, navigational, and other purposes, is essentially still a process of extrapolation, because of the large number of constants and numerical parameters which must be empirically evaluated from observation and are consequently inevitably liable to the accidental and systematic errors which can never be completely eliminated with certainty from scientific measurements. Continued extrapolation into the future with available values of proper motions and fundamental constants would lead to an increasing accumulation of error. Moreover, for problems of stellar dynamics and galactic structure, proper motions are needed in much larger number and with far less systematic error than they are yet known. Proper motions of faint stars are now largely drowned in the accidental errors of the star positions upon which they depend.

To attain the accuracy needed in navigation and other applications of astronomy, a correspondingly greater accuracy is necessary in the data from which astronomical almanacs are computed; and a still higher order of accuracy is required in the construction of the basic theories and tables, the determination of time, and the investigation of fundamental astronomical problems. Current standards could not long be maintained without continual observation of the stars and the Sun, Moon, and planets to provide a basis for improved planetary tables and fundamental star catalogs. Meanwhile, the observations give a continual check on the accuracy of existing tables and ephemerides. Moreover, they provide continuous records of the

irregular unpredictable motion of the geographic poles and the variation in the rotation of the Earth, which are essential for precise timekeeping and other astronomical purposes.

If astronomy is to continue to be characterized by the exactness and precision that have been achieved by 2000 years of continuous effort and have made it the model of perfection among the natural sciences, if the constantly higher standards of accuracy demanded by technology in the practical applications of astronomy and in the determination of time are to be maintained, and if the astrometric programs needed for the solution of many problems in astronomy and astrophysics are to be effective, it is essential that these continuous series of fundamental positional observations be carried on unbroken.