NATIONAL ACADEMY OF SCIENCES

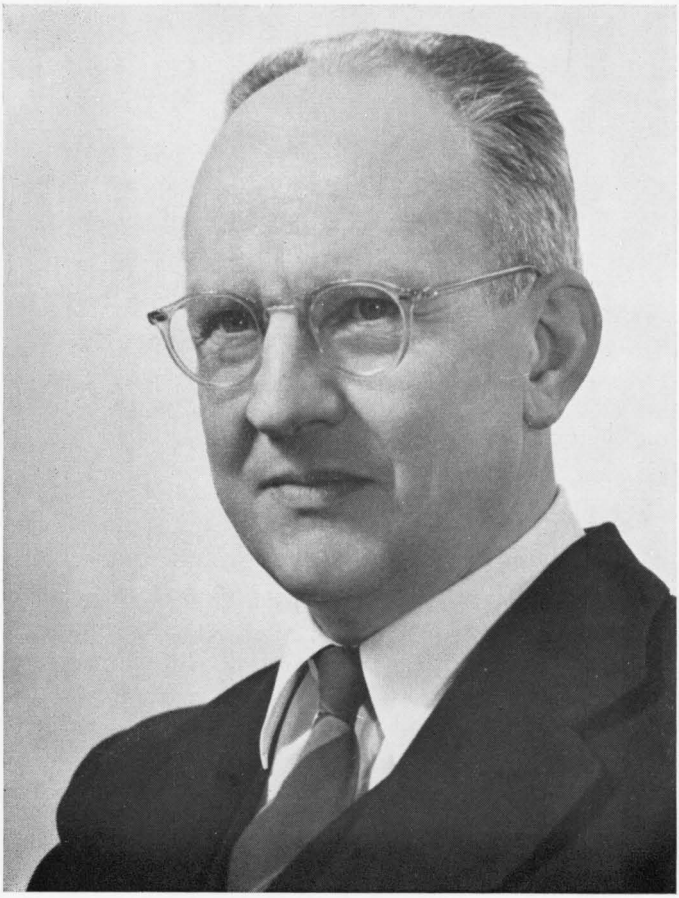
DIRK BROUWER

1902—1966

A Biographical Memoir by

G. M. CLEMENCE

Biographical Memoir



Dirk Brouwer

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September 1, 1902–January 31, 1966

BY G. M. CLEMENCE

DIRK BROUWER, who contributed more to dynamical astronomy than any other astronomer of his time, died on January 31, 1966, after a week in hospital; his death was occasioned by an acute disorder of the heart. He is survived by his widow and an only son, James.

Brouwer was born in Rotterdam, the Netherlands, on September 1, 1902, the son of a civil service employee. As a student in the University of Leiden he studied mathematics and astronomy, coming under the influence of Willem de Sitter, who in his own day was the dean of that branch of astronomy in which Brouwer was to do most of his work. Receiving the Ph.D. degree in 1927 under de Sitter, Brouwer came to the United States as a fellow of the International Education Board, spending a year at the University of California in Berkeley and at Yale University, where he was to remain the rest of his life.

His initial appointment at Yale was in 1928 as research assistant to Ernest W. Brown, who was then the greatest living authority on the motion of the moon. After rising through the usual junior ranks, in 1941 he was appointed professor, chairman of the Department of Astronomy, and director of the Observatory, and in 1944 Munson Professor of Natural Philosophy and Astronomy, posts which he held until his death.

Also in 1941, when the American Astronomical Society acquired ownership of the *Astronomical Journal,* Brouwer was appointed editor, and later senior editor, another post he held until his death.

He was elected to the National Academy of Sciences in 1951, and was awarded the Gold Medal of the Royal Astronomical Society in 1955. Among his other honors were: George Darwin Lecturer, Fellow of the American Academy of Arts and Sciences, Correspondent of the Royal Netherlands Academy, Honorary Doctor of the University of La Plata, and Corresponding Member of the Academy of Sciences of Buenos Aires. He was also awarded the Bruce Medal of the Astronomical Society of the Pacific, the decision being taken the month before his death, and the actual award being made posthumously.

Brouwer was the author (jointly with the writer) of a successful book, *Methods of Celestial Mechanics* (1961), which has also been published in a Russian translation.

He was active in the International Astronomical Union, serving six years as President of the Commission on Asteroids and Comets, six years as President of the Commission on Celestial Mechanics, as chairman of a working group on photographic astrometry, and as a member of a working group on the system of astronomical constants.

The subject of dynamical astronomy (or celestial mechanics) traditionally comprises the study of the motions of planets and satellites. In any particular case the aim is to develop mathematical expressions that will yield the coordinates of the body in question as functions of the time, such that substitution of any value of the time, past or future, will yield the whereabouts of the body. Obviously this aim is not attainable unless knowledge of the beginning and end of the solar system is available; hence in practice it is attempted to solve the problem for the span of years during which a body has been ob-

served, and to project the work as far into the future as is practicable, which in ordinary cases is some centuries.

The study of motions within a cluster of stars, or within a galaxy, is also included in dynamical astronomy, but this subject has become prominent only since 1950; Brouwer declined to interest himself in it, saying that there was plenty for him to do in the fields that he knew something about.

An indispensable adjunct of classical dynamical astronomy is astrometry, which includes the determination of accurate positions and motions of some tens of thousands of stars, to which in turn the positions of planets and satellites may be referred. Brouwer was early introduced to astrometry by Frank Schlesinger, his predecessor as director of the Yale Observatory, who devised and practiced new techniques in the field, and Brouwer never ceased to do all he could on the theoretical side for the advancement of the subject. Following Schlesinger's death, he also gave active support to the continuation of Schlesinger's astrometric program, until his own death.

Brouwer's most important contributions to dynamical astronomy proper are as follows.

He and W. J. Eckert devised a new scheme for the differential correction of orbits of planets and satellites, in which the differential coefficients are derived from the latest approximation to the orbit in the simplest possible way, with a minimum of calculation. The method is now used almost exclusively throughout the world.

He showed that, in the numerical integration of orbits, the errors in five of the six parameters increase proportionally to the square root of the number of steps of integration, whereas the error of the sixth (the position in the orbit) increases with the three-halves power of the number of steps.

He devised a plan for eliminating the systematic errors of star catalogues of position by means of selected minor planets.

He developed a new form of planetary theory, in which the use of rectangular coordinates is made to yield analytic expressions of the utmost elegance and simplicity.

He established a definite connection between Encke's comet and the Taurid group of meteors.

With W. J. Eckert and the writer he calculated precise values of the coordinates of the five outer planets for more than four hundred years. This work, the first extensive application of high-speed calculating machines to the subject, is still the standard of comparison for all similar work done since.

He established that the fluctuations in the rate of rotation of the earth are of a statistical character that would be produced by random disturbances in the interior of the earth, and in 1950 he proposed the name *ephemeris time,* which has been adopted throughout the world for the astronomical measure of time that is free from such fluctuations.

He solved the problem of the effect of the oblateness of the earth on the motions of artificial satellites. This solution, of great practical value as well as theoretical interest, is completely general, and immediately applicable to any satellite.

He solved the problem of the existence of the Kirkwood gaps in the ring of minor planets, which had baffled astronomers for half a century.

In mentioning his most important contributions I limit myself arbitrarily to ten. In fact there are many others that are hardly less important than these.

Although administrative and financial affairs did not interest him as a rule, he could be active enough when he thought the occasion required it. The most notable case in point was the construction after almost a decade of persistent effort of a twin-astrographic telescope, with the aid of the Ford Foundation, at the Yale-Columbia Southern Observatory, for the purpose of completing the extragalactic survey that had been undertaken for the northern sky by the Lick Observatory. He

lived to see the first year of active operation of the new instrument, undertaken with the aid of the National Science Foundation.

The launching in 1957 of the first artificial satellite soon led to an upsurge of interest in dynamical astronomy, to an extent unprecedented in the history of the subject. In the immediately preceding decades the number of active workers in the field had been about six in the United States, with perhaps a slightly greater number in the rest of the world. Now within a single year scores of students were seized with the desire to study dynamical astronomy, and the demand for teachers of the subject far exceeded the supply. In part the demand was generated by government laboratories having responsibility for tracking space-vehicles, but more important seems to have been the general public interest in space activities. The Yale Department of Astronomy had many more prospective graduate students applying for admission than it could accommodate.

Brouwer conceived the idea of creating a summer institute in dynamical astronomy, afterwards popularly known as SIDA, consisting of an intensive six-week course of lectures, four or five daily, which would be open to college teachers and to employees of industry and government. With the aid of the National Science Foundation six such institutes were held before his death, and they were widely acclaimed.

With a view to the more distant future, Brouwer envisioned an Institute of Celestial Mechanics at Yale, which would consist of a small resident faculty, visiting lecturers, and graduate students. With the aid of the Office of Naval Research and the Air Force Office of Scientific Research the Institute was created in 1962 and is still flourishing.

These two educational activities demonstrate that Brouwer's power of innovation was by no means limited to his own research.

One of his more notable personal attributes was absolute

integrity. His word was always his bond, in small matters as well as great ones. Several times I knew him to decline to be released from obligations that must have been onerous, even when the circumstances in which they were made had been substantially altered.

He was also exceedingly persevering. An example was his study of the English language, which he continued unremittingly to the very end of his life, although his English was better than that of most native Americans. For more than twenty years he asked me to criticize nearly everything he published for grammar, rhetoric, and style; and when we were together he often requested me to justify the form of something I had said or written.

He disciplined himself to speak without notes, and most of his lectures were models of clarity and logical development. Usually he had a book or two with him but would refer to them only at rare intervals. He had an engaging custom, while at the blackboard, of giving emphasis to his remarks by jabbing vigorously with the chalk; when it broke, which was often, he habitually caught the flying piece in mid-air without obvious exertion; it seemed to fall into his hand.

He claimed to have no appreciation of the fine arts, and indeed to be unable to distinguish two musical pitches unless they were nearly half an octave apart. But he would sit cheerfully through musical performances or visit art galleries when the amenities seemed to require it, and he was always ready with a graceful comment afterwards.

He was nearly always cheerful, even-tempered, energetic, and active, very seldom ill, never moving slowly, but always anxious to get to the pending item of business. His principal exercise consisted of walking, mowing the lawn, and shoveling snow, all of which he did vigorously. He had nothing I would call a hobby, although he enjoyed watching an occasional game

of baseball or soccer, and he could usually report the relative standings in major-league baseball at a moment's notice. He was also compassionate; among his most disagreeable duties were flunking a student and rejecting a manuscript, which he always did as gently as possible, often at considerable cost of his own time. With dishonesty, evasion, or malfeasance he had no patience; I saw his wrath break out on two occasions, and I am sure the miscreants never forgot it.

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KEY TO ABBREVIATIONS

Am. Astron. Soc. Publ. = American Astronomical Society Publications
Am. Phil. Soc. Year Book = American Philosophical Society Year Book
Astron. J. = Astronomical Journal
Astron. Nachr. = Astronomische Nachrichten
Astron. Pap. Am. Ephemeris Naut. Almanac = United States Naval Observatory. Astronomical Papers prepared for the use of the American Ephemeris and Nautical Almanac
Beob. -Zirk. Astron. Nachr. = Beobachtungs-Zirkular der Astronomischen Nachrichten
Bull. Astron. = Bulletin Astronomique
Bull. Astron. Inst. Neth. = Bulletin of the Astronomical Institutes of the Netherlands
Carnegie Inst. Wash. Year Book = Carnegie Institution of Washington Year Book
Monthly Notices Roy. Astron. Soc. = Monthly Notices of the Royal Astronomical Society
Res. Rev. = Research Reviews
Trans. Intern. Astron. Union = Transactions of the International Astronomical Union
Trans. Yale Univ. Astron. Obs. = Transactions of the Yale University Astronomical Observatory
Yale Sci. Mag. = Yale Scientific Magazine

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