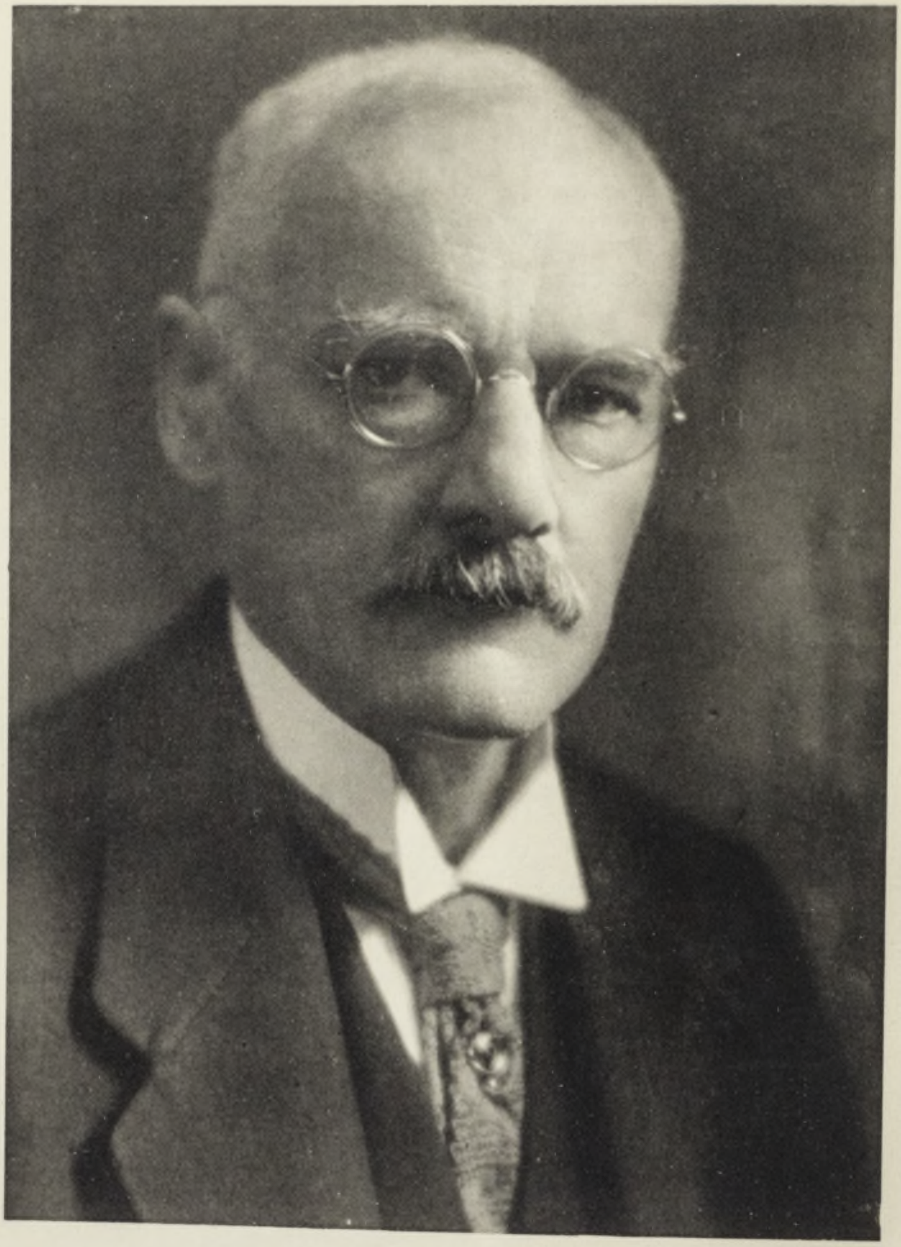

Ernest W. Brown

ERNEST WILLIAM BROWN

1866—1938

ERNEST WILLIAM BROWN was born on 29 November 1866, at Hull. In 1884 he entered Christ's College, Cambridge, as a scholar, graduated in 1887 as Sixth Wrangler, and later was made a Fellow of his College. In 1891 he became Professor of Applied Mathematics at Haverford College, Philadelphia. In 1907 he moved to Yale, and was Professor of Mathematics there till his retirement in 1934. He was then made Emeritus Professor there and continued to reside at Newhaven, Conn., till his death on 22 July 1938. He received a considerable number of academic honours which need not be enumerated, and held the rare distinction of being simultaneously both a Fellow of the Royal Society and a Member of the National Academy of Sciences; to the first he was elected in 1897, and to the second after his naturalization as an American citizen in 1923.

Brown's best known work was on the theory of the motion of the moon. Of all problems of gravitational astronomy there is none that has proved so difficult as this. The reason lies in the fact that all the ordinary methods of approximation converge so badly as to be unreliable when accuracy is called for at a pitch comparable with the observations of the moon's motion. In considering the perturbations of one planet by the rest, or the motion of a satellite round its primary, the body is usually regarded as travelling in an ellipse, and the perturbation is expressed in terms of the very small and slow changes in the eccentricity and other elements of the orbit. With the earth-moon system, even leaving out all the other planets, this will not work for a variety of reasons. In the nineteenth century there were two theories developed on these lines, those of Delaunay and of

Hansen, both of which were capable of yielding fairly high accuracy; but the accuracy was still well below that of the observations, so that it remained uncertain whether the law of gravitation was really competent to explain the moon's motion. In neither method was there hope of much greater accuracy. In 1877, however, Hill introduced a wholly new method, in which the motion was no longer based on the idea that the moon described an ellipse round the earth. Instead he based his solution on a motion in which the earth went in a circle round the sun, while the moon described a symmetrical periodic orbit round the earth, in fact a perturbed circle round it. Actually his axes were a system of moving axes with origin at the earth's centre, which rotated uniformly once a year. The eccentricity of the earth's own orbit, and the inclination and eccentricity of the moon's orbit round the earth, proved to be easier perturbations to handle in this way than with methods based on the ellipse. In any question of perturbation theory it is always difficult to decide how far the calculation shall be algebraic and how far numerical. When a numerical method is used there is the danger that some of the constants have been chosen wrong, for that may invalidate the later work. An advantage of Hill's method for the moon is that the lengths of month and year are known with a very high degree of precision indeed, so that they can be put in at the start without danger, and this saves a great deal of trouble in the subsequent calculations.

Brown followed Hill's method and succeeded in putting in all the necessary but highly complicated corrections. These included the figure of the earth and of the moon, the direct action of the planets, and indirect actions of them such as those arising from the slow change of the plane of the ecliptic. The work was enormous in its extent, as will be realized from the fact that in the various expressions to be developed not far short of two thousand terms contributed perceptibly, and in the course of evaluating them, something like five times as many had to be verified as insignificant. After the theory had been completed, there remained the great task of constructing the tables from it;

this was undertaken at the time he removed to Yale, and the university generously undertook to defray the cost of the work. In 1923 Brown's Lunar Tables superseded Hansen's as the authoritative statement of the moon's position in the Nautical Almanacs of the world.

Even now there are a few discrepancies between the tables and the observed position, but it is probable that Brown was right in his opinion that these could not be attributed to any effect of the law of gravitation. Indeed these discrepancies furnished the starting-point of some of his later work, for he was led to the suggestion that some of the fault was to be attributed to inaccurate time-keeping on the part of the earth; it was not the month that was to blame, but the day. This could be explained by the idea that the earth's surface sometimes slips on its core a little; it was an idea that found a good deal of support from other sides, and with a view to confirming it he organized an intensive study of occultations of stars, which yield the most precise determinations of the moon's position.

After he had finished his main work on the moon, he took up the difficult problem of the motion of the Trojan group of minor planets, which occupy positions not very far from the third corner of an equilateral triangle with the sun and Jupiter. One of his minor studies was connected with Pluto. It had been claimed that this planet was discovered in the same manner as Neptune, through its gravitational attraction on the other planets, but he maintained that, from its position in the sky during the period for which calculation could be applied, it was not competent to produce any observable perturbations on either Uranus or Neptune, so that its discovery was only to be attributed to a very thorough search of the sky.

Brown's work on the moon was naturally extremely laborious, but that it was possible at all was due not so much to an infinite capacity for taking pains, as to the capacity by which he could reduce those pains to a finite degree. He was always ready to vary the methods of his predecessors so as to make the work more manageable, and indeed not long before his death he

discovered that his own methods could be enormously shortened. He made the experiment of taking his axes to rotate in a month instead of a year and was surprised to find how much the problem of the moon was simplified. In a paper of which he read the proofs a few days before his death he remarks that with these new axes, and helped by the great recent developments of calculating machines, "we have been able in a year or two to test and extend calculations which took me nearly twenty years to carry out with the old fashioned methods". The main outcome of this new work was to confirm the old by showing that his suspicions of certain points in it had been unfounded.

Brown started work on gravitational astronomy under the influence of George Darwin, and continued to be a close personal friend with him and his family for the rest of his life. His rather austere subject of study in no way affected his personal character, which was genial and sociable. He frequently revisited England in the summer, making Cambridge his headquarters, and renewing all his old friendships. During and after the War these visits became a little less frequent, and he spent much of his vacation time on a derelict farm he had bought not very far from New-haven. His manner of life there was singular. He lived completely alone. As soon as it was light in the morning, or even before, he would do several hours of calculation lying in bed. Then, perhaps after some more sleep, he would rise, cook the breakfast, do the 'chores', and then return to his mathematical work. In the afternoon he would drive over to see some of his friends in the neighbourhood and return after supper. He never married, but did not develop the characteristics that so often go with the single state, so that he continued a genial friend to the last. As far as one may foresee, considering that he finished off the most difficult of all planetary problems, and that the interest of astronomers has shifted into other directions, it may well be that Brown will rank as the *last* of the great gravitational astronomers in the succession of Newton, Laplace, Adams, and Hill.

C. G. DARWIN