SIR ROBERT STAWELL BALL, 1840–1913.

ROBERT STAWELL BALL was born at Dublin on July 1, 1840. His father, Dr. Robert Ball, was born at Cove, co. Cork, in 1802, from whence he migrated to Dublin in 1827 upon his appointment to a post at the Castle. Dr. Ball took a keen interest in Natural History, and the Dublin Zoological Gardens are largely due to his persevering and unstinted labours. He died at a comparatively early age in 1857, leaving a widow and seven children, three sons and four daughters. Robert Stawell was the eldest of the sons, who all became distinguished citizens of Dublin, Dr. Valentine Ball becoming the Director of the Science and Art Museum, and Sir Charles Ball the well known surgeon.

After some years at a preparatory school in Dublin, Robert was sent in 1851 to Dr. Brindley's school at Tarvin, near Chester, where he received his early training in Mathematics from the Rev. Theophilus B. Rowe, afterwards headmaster of Tonbridge School. He remained at Tarvin till his father's death. In October, 1857, he was entered as a student at Trinity College, Dublin. He soon showed his aptitude for Mathematics and won numerous prizes. In 1860 he obtained a scholarship and the Lloyd Exhibition. In 1861 he was Gold Medallist in Mathematics, first Gold Medallist in Experimental and Natural Sciences, and University Student. He competed three times for a Fellowship at Trinity College, but was not successful, the successful candidates on two of the occasions being W. S. Burnside and H. S. Tarleton.

Ball's interest in Astronomy was awakened by Mitchell's 'Orbs of Heaven,' a book he read at school at a time when he should have been asleep. At college he studied Brinkley's 'Astronomy,' the 'Principia,' and the 'Mécanique Celeste.' In 1865, at the instance of Dr. Johnstone Stoney, he was invited to become tutor to the sons of Lord Rosse at Parsonstown. He accepted the post on the condition that he should have access to the Observatory and the privilege of using the great telescope. He worked with the 6-foot reflector from January, 1866, to August, 1867, making micrometer observations of the positions of small nebulæ. It is pointed out by Dr. Dreyer that he was the first observer with the instrument to correct the observed position angles for the error due to the instrument not being equatorially mounted, but supported at its lower end by a universal joint, the fixed axis of which was horizontal, in the east and west direction. This procedure, which materially improved the observations, was a natural outcome of Ball's geometrical instincts. About this time the application of the spectroscope to the problems of Astronomy was making great headway. Although Sir Robert Ball took no active part in this, he was keenly interested in it, an interest quickened by a visit to Sir William Huggins' Observatory at Dulwich.

In 1867 the Royal College of Science was founded in Dublin, and Ball left Birr Castle to become the first Professor of Applied Mathematics and Mechanism. He was well fitted for this post by his mathematical knowledge and ability and his experimental skill, but especially by his gift for lucid exposition. He was one of the first in Great Britain to introduce the system of C.G.S. units in his class teaching. In addition to his class lectures he gave some evening lectures of a more elementary character, and here showed and developed his genius as a popular lecturer. In 1871 he published a work on 'Experimental Mechanics,' the outcome of his evening lectures. This was the first of the many popular books he wrote.

In 1870 Ball read a paper before the Royal Irish Academy on "The Small Oscillations of a Rigid Body moving about a Fixed Point under no Forces." This was the first of his many memoirs on the theory of screws. The whole series was published in a single volume by the Cambridge University Press in 1900. A critical account of this important contribution to Mathematics is given at the end of this notice.

In 1874 Ball was appointed successor to Brünnow as Royal Astronomer of Ireland and Andrews Professor of Astronomy in the University of Dublin. The Observatory, situated at Dunsink, a few miles from Dublin, possessed an excellent 12-inch telescope, the gift of Sir James South. This had been employed by Brünnow in the investigation of stellar parallax, a branch of astronomy which his predecessor Brinckley had attempted half a century previously. Dr. Ball decided to pursue this important but difficult research, and commenced with the star 61 Cygni, for which he obtained a result in good agreement with the classical determination by Bessel. From 1876 to 1881 he prosecuted an active search for stars of large parallax. In all, 368 stars were examined and the results published in the Dunsink Observations. In the preface to this memoir he states: "It is, of course, well known that up to the present no parallax of a star has been detected which exceeds one second of arc. In the majority of cases the parallax is much less, even if it is appreciable. But when we reflect that not one star out of every 10,000 has yet been regularly examined for parallax, it is obvious that it would be rash to conclude that there are no stars nearer to us than any of those of which we already know the distance." The results he obtained were negative, but it was nevertheless of interest to demonstrate that none of the stars presumably near the solar system were so close as to have a parallax as great as one second. The more refined observations of the heliometer and the photographic refractor were shown to be necessary for the measurement of the small displacements of even the nearest stars.

In February, 1892, Sir Robert Ball succeeded Prof. Adams in the Lowndean Chair of Astronomy and Geometry and the Directorship of the University Observatory at Cambridge. During his directorate the valuable catalogue of stars, commenced in Adams' time, was completed and published by Mr. Graham. A photographic telescope, mounted on a novel plan according to a design by Dr. Common, was erected for the purpose of carrying on researches in stellar parallax. This instrument was put to very efficient use by Mr. Hinks in observations of the planet Eros in 1900 and 1901 for the determination of the solar parallax, and by Mr. Hinks and Prof. H. N. Russell (then an advanced student of the University) for observations of stellar parallax. Sir Robert Ball maintained an interest in these parallax researches, but left their active prosecution to Mr. Hinks and Mr. Russell.

As a lecturer on Mathematical Astronomy, Sir Robert Ball gave his pupils a lucid exposition of the classical writers on celestial mechanics. He wrote a text-book on 'Spherical Astronomy,' intended for the use of University students. This book contains a chapter on the theory of astronomical instruments, which is of special interest, as showing the geometrical bent of his]mathematical interests.

Sir Robert Ball rendered great service by his popular books and lectures. These awakened an interest in astronomy among a very wide circle of readers and hearers. A lecture which he delivered at the Midland Institute at Birmingham in 1881 attracted particular attention and established his fame as a popular expositor of science. This lecture, entitled, "A Glimpse through the Corridors of Time," gave in popular language an outline of Sir George Darwin's theory of the tidal evolution of the Moon. As a lecturer he possessed great lucidity and brought abstruse subjects within the comprehension of his audiences. His delightful gift of humour was always at hand to enliven any dull parts of a lecture and retain the attention of his hearers. He lectured in most of the large towns in Great Britain and in many cities of the United States and in Canada. Probably more than a million people have heard him lecture.

Among his many popular books, 'The Story of the Heavens,' published in 1886; 'The Story of the Sun,' published in 1893; and 'Great Astronomers,' published in 1896, may be specially mentioned. They are written in a very pleasant style, and the lives of Astronomers, including those of Hamilton and Adams, his predecessors at Dunsink and Cambridge, are told in a delightful manner.

In 1884, Ball became Scientific Adviser to the Commission of Irish Lights, in succession to Tyndall, and always took the greatest delight in the annual cruise of the Commissioners round Ireland to inspect the lighthouses. In 1886 the honour of knighthood was conferred upon him. He was elected a Fellow of the Royal Society in 1873 and served on the Council in 1897–8. He was President of the Royal Astronomical Society, 1897–9.

In 1868 he married Frances Elizabeth, daughter of the late Dr. W. E. Steele, Director of the Science and Art Museum, Dublin. He leaves four sons and two daughters.

Sir Robert Ball died at Cambridge on November 25, 1913, after an illness which lingered for over two years. He was a most warm-hearted and kindly man and had a large circle of friends attracted by his genial manner, ready sympathy, and delightful humour.

Ball's 'Theory of Screws' gives a very complete geometrical treatment of the problems of small movements in rigid dynamics, and in that respect is unique among English books. The small first edition appeared in 1876. Ten years later was published the German 'Theoretische Mechanik Starrer Systeme' of Gravelius, founded mainly upon Ball's memoirs. The "twelfth and concluding" memoir in the Proceedings of the Royal Irish Academy was dated 1898, and the large and comprehensive work on the 'Theory of Screws' was published in 1900.

The keynote to the whole method consists in the use of the "screw," consisting of a line in space together with an associated length. This geometric entity has a double use. It gives the axis and the pitch of either a "wrench," representing any system of forces, or of a "twist," representing the most general small displacement of a rigid body. The derivative relationships of which the method is built may be briefly described. Two screws are defined as "reciprocal" when a wrench on one screw does no work for a twist on the other, and so also conversely. A "principal screw of inertia" is such that an impulsive wrench on it produces instantaneous twist on the same screw. "Conjugate screws of inertia" are such that a twist on either is produced by an impulsive wrench on a screw reciprocal to the other. Similarly for the forces of restitution: a "principal screw of potential" is such that a twist on it evokes a wrench on the same screw, and "conjugate screws of potential" are such that a twist on either evokes a wrench on a screw reciprocal to the other. A "harmonic screw" is such that a twist on it evokes a wrench which produces a twist on the screw itself. A harmonic twist on such a screw is thus one of the normal modes of oscillation of the body about its position of equilibrium. These relationships are intimately connected with the "kinetic screw complex," consisting of the screws for twists on which the kinetic energy is zero, and the "potential screw complex" for which the potential energy is constant.

With this apparatus a thorough investigation is made of the behaviour of a rigid body with any number of degrees of freedom from one to six. In the case of two degrees of freedom the notable "cylindroid" presents itself, as the cubic surface locus of the screw-axes of all possible twists. But the cylindroid is used fundamentally through the whole work, and a perspective view of the surface figures naturally as a frontispiece to the volume. Though not the actual discoverer of the surface (Hamilton and Plücker had found its chief property earlier), Ball certainly counts as its chief patron. He took always a lively interest in any development of its properties, and a beautifully made model placed in the collection of Cambridge University serves as a memento of its former owner.

If the geometry of the linear complex had developed earlier, its immediate application to infinitesimal rigid dynamics should have followed as a logical consequence; but the subject was in its infancy, and Ball had to investigate much of the geometry for himself as he progressed. This he was well able to do, and he seems to have made independent discovery of some of the theorems of line-geometry. The conciseness and elegance, in particular, of the treatment of the case of two degrees of freedom by a circular diagram represents evidently his native geometric faculty. Perhaps some of the later developments seem less natural. Any general system of bodies is dealt with under the description of a "screw-chain"; but the arbitrary assignment of a definite sequence to the bodies forming the chain seems artificial as a mode of treatment. In the case of the so-called "permanent screws" the terminology at least seems inapt, for the "permanence" is only transient.

For a most admirable and appreciative survey of the scope of Ball's work on screws, reference may be made to a review by Henrici ('Nature,' June 5, 1890, pp. 127–132) of the German treatise above mentioned. An excellent account was given by Ball himself in his presidential address to the Mathematical Section of the British Association in 1887. He there uses some geometrical abstractions, quaintly personified, as speakers in a discussion; and, under this whimsical garb, reveals the essence of his methods very pertinently and clearly. Through all Ball's work there shows a fine enthusiasm for his subject and a most generous appreciation of the discoveries of others. In the year 1879 the Royal Irish Academy awarded him the Cunningham Gold Medal, and his name thus occurs in a list which includes also those of Casey, MacCullagh, Hamilton, Jellett, and Salmon. By his many and excellent contributions to the geometry of kinematics and dynamics, Robert Stawell Ball assuredly takes an honourable place on the roll of Irish mathematicians.

F. W. D. and G. T. B.