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SCHUSTER, SIR **Arthur** (1851—1934), mathematical physicist, was born Franz Arthur Friedrich Schuster on 12 September 1851 in Frankfurt-am-Main, Germany, the middle son of the three sons and one daughter of Francis Joseph Schuster (1823-1906), textile merchant and later banker, and his wife Marie (1830- ?1898), daughter of Hofrath Max Pfeiffer, banker, of Stuttgart. Following their marriage in 1849, his parents converted from Judaism to Christianity. Their children were baptised in 1856 and brought up in that faith (although Arthur apparently had little subsequent interest in religion).

He began elementary school in 1856. His interest in science began during his years at Frankfurt Gymnasium (1863-8), encouraged by his private tutor Harald Schütz (later professor of mathematics at the Gymnasium). Following Frankfurt's annexation by Prussia in 1866, his father made 'financial arrangements' (Schuster, 1932: 40), to ensure that Arthur and his brothers became Swiss citizens, thereby avoiding the threat of service in the Prussian army, and in 1868-70 he attended the Academy in Geneva. In 1869, his father moved with his family to take up a position in the family textile business which had transferred to Manchester, then centre of the cotton-trade, in 1811. Arthur rejoined his parents in 1870, and he and his siblings became British citizens in 1875. His elder brother Ernest Joseph (1850-1924) would become a barrister and authority on international law; his younger brother (Sir) Felix Otto [q.v.] a leading banker; and his sister Paula (b. 1863) later married (Sir) Lawrence Jones.

Determined on a scientific career, after a frustrated year as a wages-clerk in Schuster Brothers, partly alleviated by attendance at (Sir) Henry Roscoe's [q.v.] evening-classes in chemistry at the Owens College (now the University of Manchester), his mother and Roscoe persuaded his father to let him begin full-time studies in October 1871. He took mathematics under Thomas Barker [q.v.], physics under Balfour Stewart [q.v.] and began research with Roscoe on the spectraum of hydrogen and nitrogen. After a rather disappointing year with G.-R. Kirchhoff (1824-1887) at the University of Heidelberg, he gained his Ph.D. and returned to Owens as an unpaid demonstrator in physics. He spent the summer and autumn of 1874 working with W.E. Weber (1804-1891) in Göttingen and H.L.F. von Helmholtz (1821-1894) in Berlin. On return to England he was invited, because of his knowledge of spectrum analysis, to lead an expedition to Bangkok, Siam (Thailand) to photograph the coronal spectrum

during the total solar eclipse of 6 April 1875. This aim was not entirely successful, but he later participated in similar expeditions to Colorado, 1878; Egypt, 1882 (where he took the first successful photograph of the coronal spectrum); and the West Indies, 1886.

He returned to Owens in November 1875 and lectured on James. Clerk -Maxwell's [q.v.] *Treatise on Electricity and Magnetism.* SchusterIn May 1876, Schuster visited Maxwell at the Cavendish Laboratory, Cambridge, to discuss undertaking research on the diamagnetism of rocks but, on entry that October, he began a study of oxygen emission spectra transferred to the Cavendish Laboratory, Cambridge, in 1876 . to work with Clerk-Maxwell on the spectra of oxygen and nitrogen Following Maxwell's death in November 1879, Schuster, and later worked with J.W. Strutt (Baron Rayleigh) [q.v.] to obtain a more accurate value ofredetermine the the standard ohm as a unit of electrical resistance in absolute units.

In 1881, Schuster was appointed professor of applied mathematics at Owens, which had become one of the colleges of the newly-constituted Victora University, and. would succeed Stewart as professor of physics in 1888. In 1887 Schusterhe married 'Cary' (Emma Caroline Elizabeth) (Cary)Loveday (1867-1962), eldest of the four daughters of George Loveday, gentleman, of Wardington, Oxfordshire. They had one son and four daughters. Both Schuster and his wife were strong supporters of emancipation for women; she played a leading role in the Owens Athletic Union, the staff bicycling club, and acted as hostess at her husband's weekly Physical Colloquia.

In 1888 Schuster succeeded Stewart as professor of physics. In 1883, Schuster moved on from 'spectroscopy'Continuing his work on spectra (a term he introduced the term 'spectroscopy' in 1882), to continue research on low-pressure electrical discharge in gases, which he had begun at Cambridge. He suggested (1884) that the mechanism involved must be analogous to that of electrolysis in liquids, involving 'dissociation' of the gas into two chemically alike, but oppositely charged, 'particles' ('ions'). He was the first to use magnetic deflection to determine the ratio of the average charge to mass of the particles present in the luminous discharge of nitrogen. However, because of uncertainty in his experimental result ($10^3 < e/m < 10^6$ e.m.u.) and on conduction of electricity through gases, he was the first to recognise (1884) that the latter depended on the transport of electricity by charged particles (ions) moving through the gas. Using magnetic deflection, he made the first measurements of the charge/mass ratio of cathode rays (1890), Schuster (1890: 547) , but because

his measurements had large uncertainty, he concludeddisbelieved his evidence which suggested that 'to an order of magnitude' the ratio was sufficiently similar to that for 'an atom of hydrogen in water' (10^4 e.m.u.)the ratio might be far smaller than that of hydrogen (known from electrolysis), and concluded that it confirmed his hypothesisthe carriers must be fast-moving negatively-charged atoms of gas. IIn 1897 (Sir) J.J. Thomson [q.v.], using an improved on Schuster's experimental method (finding $e/m \approx 10^7$ e.m.u.) and deduced, showed that these fundamental particles involved, named 'electrons' by George Stoney (1826-1911) in 1894, must bemust be sub-atomic in size. Feffer (1989) has argued that, contrary to earlier claims that Schuster's work anticipated Thompson's discovery, Schuster had no interest in the nature of cathode rays (named by Eugen Goldstein (1850-1930) in 1876), nor the carrier particles, *per se*.

By 1896, Schuster's experimental work had broadened into electro-chemistry, optics and X-radiography. Encouraged by Stewart, he now turned to earth-physics and used the mathematical technique of harmonic analysis to disprove C.G. Knott's [q.v.] claim of periodicity in earthquake occurrences (1897). Schuster's lasting legacy is, however, his development of the periodogram (1897-8), the first practical tool for identifying statistically important frequencies present in a time-series of observations. He used it to support Stewart's conjecture that variation of the terrestrial magnetic field was related both to electrical currents in a conducting layer of the upper atmosphere (the 'Heaviside layer' discovered by the physicist Oliver Heaviside (1850-1925) in 1902) and induced electrical earth-currents, showing both had recurrence periods of c. 26 days.

Having presided over the building of the new Physical Laboratory of Owens College (1900), when the University of Manchester was created in 1903, Schuster became dean of the faculty of science (1903-5), but in 1907, partly as a result of strain and from a wish to further the cause of international science, he resigned his chair, having first ensured that (Lord) Ernest Rutherford [q.v.] would become his successor.

Although regarded by his contemporaries as a mathematical physicist of exceptional ability, Schuster was also a capable administrator and teacher, and a passionate advocate for the role of science in education and industry. Elected a Fellow of the Royal Society in 1879, he began service as its secretary in 1912, moving home in 1913 from Kent House, Victoria Park, Manchester, to Twyford, Berkshire, in order

to facilitate this work. A strong supporter of scientific links between Britain and Germany, in 1899-1904 he helped the International Association of Academies to become fully established.

Refusing to credit rumours of Germany's growing militarism, Schuster was travelling to the Crimea to observe an eclipse when World War I began, and had to hurriedly return via Egypt. In the previous year, he had attended the Berlin conference of the British-German Foundation to discuss exchange studentships, and his older brother (president of the 'German Colony' in London), had organised a banquet to celebrate the jubilee of the Kaiser's reign. The Schuster family now found itself subjected to anti-German prejudice both in the press and, in Arthur's case, from a few in the Royal Society, such as H.E. Armstrong (1848-1937), A.B. Bassett (1854-1930) and (Sir) E.R. Lankester (1847-1929). Sir Felix Schuster had eventually to issue a press-statement pointing-out the family's loyalty to Britain and that they all had sons serving in the British Army. On the day of Arthur's presidential address to the 1915 British Association meeting in Manchester, he learnt that his own son, serving in the Dardanelles, had just been wounded. Admirably supported by the Council of the Royal Society, Schuster served as secretary throughout the war, and was then elected vice-president (1919-20) and foreign secretary (1920-24). He also served as secretary of the International Research Council (1919-28) and on the management committees for the Meteorological Office (1905-32) and National Physical Laboratory (1899-1902, 1920-25). During his career he published six books, including *Introduction to the Theory of Optics* (1904), and some 150 scientific papers.

His honours included the Order of the White Elephant of Siam (1880) and a knighthood in 1920; doctorates from the universities of Geneva (1909), St. Andrews (1911) and Oxford (1917); and the award of the Royal, Rumford and Copley medals of the Royal Society (1893, 1926 and 1931).

Schuster's rather refined features were always graced by a beard and moustache and his use of spectacles in later life gave him a more serious look. Although described as having a generally serious demeanour and retiring nature, he was regarded as kindly, a good conversationalist and something of a wit, although he could occasionally upset others by espousal of unconventional views (e.g. his disapproval of the granting of external degrees by London University, and the need for a radical reorganization of the Meteorological Office). Rutherford (in Eve 1939: 167) wrote that Schuster 'unlike most professors is a wealthy man,' but he was generous with it, e.g., purchasing radium

for the Physical Laboratory and two seismographs for the Eskdalemuir Observatory; endowing readerships in mathematical physics at Manchester and meteorology at Cambridge; and contributing generously to funds of the Royal Society and the International Union for Co-operation in Solar Research. In his youth, Schuster enjoyed walking and climbing, and later cycling and motoring. Since boyhood he had enjoyed sketching and landscape-painting and 'usually carried his complete outfit with him' (Hale 1935: 105) when travelling, even to scientific meetings. Unfortunately, this ended in 1923 when he lost an eye in a golfing accident and his health, apparently never very robust, gradually declined. He died of cerebral thrombosis at Yeldall, Twyford, near Reading, Berkshire on 14 October 1934 and was buried at Brookwood Cemetry, Woking on 17 October.

[1613518 words] RICHARD J. HOWARTH