The school of Abetti has spread all over Italy: several Observatories are or have been directed by some of his students and collaborators.

Abetti was not only a famous scientist and a very clear scientific writer. He was a man of warm humanity and vast interests. I worked in Arcetri under his directorship from 1945 to 1954; to me he was not only a master of science, but also a master of democracy and humanity.

MARGHERITA HACK

ROBERT D'ESCOURT ATKINSON

Professor Robert Atkinson, former Chief Assistant at the Royal Observatory, Greenwich, was remarkable for the wide diversity of his contributions to astronomy. His early career as a physicist led to pioneering application of nuclear physics to the problem of energy generation in stars, which was recognized by the Society in the award of the Eddington Medal. After the war he was Officer in Charge at Greenwich when Spencer Jones had moved to Herstmonceux, and he was heavily involved in administration of the move of the Royal Observatory. During this period, until his retirement from RGO, his outstanding scientific insight and his mechanical ingenuity were devoted to problems of precise positional astronomy. Unfortunately, at that time, circumstances prevented the fulfilment of many of his ideas. Nevertheless he continued to make substantial contributions to fundamental astronomy for the rest of his life. Shortly before leaving Herstmonceux, and during the following decade at the University of Indiana, he published several papers on general relativity. His mechanical prowess is perhaps best exemplified by the magnificent astronomical clock which he designed for York Minster. He was invited to do this by the Dean of York during the summer meeting of the Society in Leeds in 1952. It was constructed by craftsmen in the workshop at Greenwich and was unveiled by HRH the Duke of Edinburgh in 1955 as a war memorial to British, Commonwealth and Allied airmen who flew from airfields in the north-east of England during the Second World War.

Robert d'Escourt Atkinson was born on 1898 April 11, near Rhyader in North Wales, where his father was an engineer working on the construction of the Elan Valley Reservoir. His middle name is that of a family which came over with William the Conqueror and ultimately became Ashe, his mother's maiden name. His maternal grandfather, Dr Isaac Ashe, was Medical Director of the Dundrum Criminal Lunatic Asylum near Dublin, where he was murdered by an inmate. His father's father, also Robert Atkinson, was Professor of Sanskrit and Comparative Philology at Trinity College, Dublin, and became President of the Royal Irish Academy.

The eldest of five children, Robert was taught at home by his parents until he was ten. By the age of four he could read fluently and also showed considerable mechanical aptitude. At this age, with some encouragement from his father, he successfully cleaned and oiled a small clock! Later, the family moved to Manchester, and, at the age of twelve, he won a foundation scholarship to Manchester Grammar School where he was on the classical side. During his boyhood he was a very active Boy Scout. Like the rest of the family he was also a keen cyclist, and, later, he won several cups in London to Gloucester motor-cycle reliability trials. He became an accomplished pianist although he had very little tuition.

In December 1916 he won an Open Scholarship in classics to Hertford College, Oxford, but before taking this up he joined the army in 1917, with a commission in the Royal Field Artillery; he was posted to 7th Division and saw active service in Italy.

On being demobilized he took up residence in Oxford. He had decided not to read classics, but before being allowed to read physics he had to take Mathematical Moderations in which he obtained a good second. He describes the last year before his finals in the following note which was found among his papers

> 'Lindemann (Lord Cherwell) took an interest in me. He had realized that the presence of TiO_2 (really TiO) in the spectra of cool stars meant that one could work out the equilibrium conditions, and he wanted me to determine the specific heat at low temperatures of Ti and TiO_2. I worked 54 hours a week and didn't get it. I said I would have to drop it by Christmas before my finals, and I worked for my finals from then until the summer. Actually, on thinking things over I realized that solid and liquid Ti and TiO_2 were irrelevant; it must be a pure gas reaction. I worked it out, and got a pressure much less than was assumed to hold in stellar atmospheres.'

This was the topic of his first paper (*Mon. Not. R. astr. Soc.*, **82**, 396, 1922) which appeared before he took his finals, in which he obtained first class honours. He remained in Oxford for a further four years, as a research fellow at Hertford and demonstrator in the Clarendon Laboratory, where he published papers on thermodynamics and atmospheric physics.

In 1926 he was awarded a Rockefeller Travelling Fellowship to study at Göttingen under James Franck. After two years there he was awarded the degree of DPhil for a dissertation on the recombination of positive ions and free electrons and was appointed Assistant at the Technische Hochschule, Berlin. In 1929 he became Assistant Professor, and subsequently Associate Professor, at Rutgers University, New Brunswick, New Jersey.

In Berlin his interests turned to nuclear physics and the barrier penetration theory developed by Gamow. Together with F.G.Houtermans, he pioneered the application of this theory to thermonuclear fusion in stellar interiors as a source of energy generation and nuclear synthesis of the elements, addressing the question (as they put it) 'wie kann man einen Helium-Kern im Potenzial-Topf kochen?' By integrating over the Maxwellian distribution they obtained a reasonable rate for proton captures on light nuclei (this was revised a decade later by Gamow and Teller on the basis of better nuclear data but the order of magnitude was correct) and they were the first to visualize this process as a cyclic one involving the successive capture of four protons followed by emission of an α particle – the essential property of the C–N cycle later proposed by Bethe and von Weizsäcker. They thus showed that only a two-body nuclear process was required at each stage – as opposed to the wildly improbable coming together of four protons and two electrons – and thereby removed the most fundamental objection current at that time to nucleosynthesis as a source of stellar energy. Atkinson himself proceeded to develop this theme in two major papers on 'Atomic Synthesis and Stellar Energy' published in the *Astrophysical*

Journal in 1931 and a third one in 1936, which made a number of arbitrary and now outdated assumptions but also contained valuable insights that were confirmed by subsequent work based on more detailed knowledge of the underlying physical processes. He showed that the Atkinson–Houtermans theory led to a steep temperature dependence of nuclear reaction rates, broadly consistent with the small range of central temperatures along the main sequence anticipated by Eddington and inconsistent with the central point-mass models suggested by Milne, and that the brightest stars have but a short nuclear lifetime. He assembled arguments in support of the 'short' time-scale for the age of the Universe and was the first to point out that white dwarfs do not need any release of nuclear energy to maintain their luminosity. He discussed many other ideas, then less familiar than now; the significance of mixing in stars, of gravitational contraction in certain stages of a star's evolution and of differing neutron capture cross-sections among the heavy elements. He boldly contended that the cosmic abundances of the elements could be accounted for by processes in stellar interiors, a view which grew to be generally accepted (though in a significantly different form and on very much firmer grounds) for most of the elements after the late 1950s. He had to wait nearly 30 years for full recognition of this important work until in 1960 he was awarded the Eddington Medal of the Society.

In 1937 he turned down the offer of an appointment at Princeton under H.N.Russell to become Chief Assistant at the Royal Observatory, Greenwich, in succession to Woolley. Ever since the appointment of the Rev. Robert Main in 1835, Greenwich Chief Assistants had, with one exception, been appointed in their early or mid-twenties, and it can be seen in retrospect as an unfortunate decision for Atkinson, already well established in his career, to take up the post at the age of 39.

In 1940 he was seconded to the Admiralty for work on de-gaussing of ships, and was posted to Alexandria where he took charge of all such work in the Eastern Mediterranean. In 1942 he was sent to Washington as Scientific Liaison Officer for de-gaussing and obtained the adherence of the United States to the major features of the British theory. Later, in 1952, he received an award from the Royal Commission on Inventions for his contributions to de-gaussing.

From 1943, after de-gaussing had become a routine operation, Atkinson, at the specific request of E.P.Hubble, was employed part-time, and later full-time, on the application of astronomical techniques to photogrammetry, at the Ballistics Research Laboratory, Aberdeen, Maryland.

He returned to Greenwich in 1946. As he was fluent in German, he was sent on a visit to European Observatories to find out what help was needed to re-establish them after the war. At Annenheim in Austria he discovered that a solar tower had been confiscated by the RAF who found it useful as a radar station and refused to release it. He then went straight to British C-in-C and suggested that the Royal Engineers build a new tower; the original dome, which had been purloined by the local inhabitants, could be recovered by suitable payment in cigarettes! The plan was successful and the tower is still known as the 'Atkinson Turm'.

Atkinson's wartime experience in photogrammetry at Aberdeen clearly influenced his future scientific work at Greenwich and Herstmonceux. He became interested in the accurate measurement of star positions, a major part of the work of the Royal Observatory. In 1947 he published a paper on 'A proposed mirror transit-circle' (*Mon. Not. R. astr. Soc.*, **107**, 291), a revolutionary concept which would eliminate several of the serious difficulties which beset the conventional transit-circle. In the mirror transit-circle, the moving telescope is replaced by a plane mirror which rotates with its normal in the plane of the meridian, the telescope itself remaining fixed horizontally. By means of this arrangement, the differential tube flexure between objective and micrometer is eliminated. Toward the end of his career at RGO a prototype mechanical mounting was constructed and he himself carried out extensive tests of its performance, which met his own very stringent requirements. In the meantime he turned his attention to the measurement of tube flexure in classical instruments. This was generally assumed to vary sinusoidally from zero in the zenith, the single coefficient being determined either by circumpolar observations or from horizontal collimators. It is well known that systematic declination errors in star catalogues would arise if flexure contained harmonics higher than the first. In 1955 Atkinson reviewed the whole problem (*Mon. Not. R. astr. Soc.*, **115**, 427) and proposed an ingenious method of measuring flexure by means of an optical square or 'pentag' mounted in front of, but independently from, the objective. It is a tragedy that, just at the time when Atkinson's fertile inventiveness was being turned to a field of astronomy which had been working on well-established lines for more than a century, support for meridian astronomy, on the scale hitherto approved, was not forthcoming, and it was a particular disappointment to him when funding for the mirror transit-circle was stopped. But fundamental astronomy continued at Herstmonceux with the Cooke transit-circle which was first installed at Greenwich in 1933, and Atkinson devised an auto-collimation technique for calibrating the pivot errors, which was successfully implemented.

Atkinson's interest in positional astronomy was not confined to meridian observations. The accurate determination of the position of the Moon had always been a problem of major importance, historically because of its use for navigation, and in more recent years as a means of determining Ephemeris Time. In 1948 he carried out a novel experiment at the total solar eclipse of November 1 from a point just outside the zone of totality, near Mombasa. During the eclipse, the rapid change of position angle of the line of cusps was recorded with a cine-camera, and timed relative to the Rugby time signal. Very accurate measurements of the relative positions of the Sun, Moon and observing station were obtained; this involved the first use of the detailed charts of the lunar limb which had been prepared at the US Naval Observatory by C.B.Watts. Although the 1948 experiment was successful a more ambitious expedition in 1952 to the Sudan and the Persian Gulf failed mainly because of weather conditions.

From the 1930–31 Eros campaign, Spencer Jones derived a value of the solar parallax which, by 1953, was thought to be too small by some four times the quoted probable error. This indicated the existence of a systematic error, or that the probable error had been underestimated. Atkinson investigated both these possibilities and found evidence that flexure in the Greenwich Astrographic telescope, which was only one of the many telescopes used in the campaign, could account for an error of the size and sign actually suspected; he also pointed out an oversight which had led to an underestimate of the error. At the time he was refused permission to publish a paper on this subject, but he has given an account of it in his last paper (*J. Hist. Astr.*, **xiii**, 77) which appeared very shortly before he died.

In 1964 Atkinson retired from RGO and moved to the University of Indiana at Bloomington where he became successively Visiting Professor, Adjunct Professor (in 1973) and Professor Emeritus (in 1979). During this time he wrote several papers developing his ideas on general relativity within the framework of Euclidean geometry. He taught courses in relativity, binary stars and positional astronomy. His continued interest in fundamental astronomy is shown in a series of papers in which he argued strongly against the use of the Earth's rotation axis as the definition of the instantaneous pole of celestial coordinates, since latitudes and longitudes of observatories theoretically have rapid though small quasi-diurnal changes when referred to this pole. This had been pointed out earlier by Sir Harold Jeffreys, but it was Atkinson's persistence which persuaded the IAU at the Grenoble meeting in 1976 to adopt a redefinition of the pole for the new theory of nutation. Atkinson's practical ingenuity was harnessed once more when, in 1977, he was invited to design a 'standard time' sundial to honour an alumnus of Indiana University. He supervised the construction of this instrument which now stands on the Bloomington campus, and actually engraved it himself.

He was elected a Fellow of the Society in 1937 and served as Secretary in 1940–41. He was a founder member of the Institute of Navigation, becoming a Fellow in 1953, and was President of the British Astronomical Association in 1960–61. In 1977 the minor planet '1827 Atkinson' was named in his honour. He received an unusual honour from his old University of Göttingen in 1978 when he was sent a formal diploma 'renewing' his doctorate, earned 50 years before; this was awarded 'in recognition of his pioneering work on atomic synthesis in stellar interiors'.

His last visit to the Society was in 1980 March during a world tour which included a visit to India with the American Astronomical Society for the total solar eclipse in February of that year. He died at Bloomington, Indiana, on 1982 October 28 and leaves a widow, Irmin von Holten Atkinson, whom he married in 1930.

With his death, astronomy has lost a man of outstanding theoretical and practical ability. All his work was marked by meticulous attention to detail. His natural shyness made his personal relationships not always easy; nevertheless all who were privileged to work closely with him on scientific problems will remember with gratitude his patience and inspiration.

C.A.MURRAY

(In preparing this obituary of Robert Atkinson, I am deeply grateful to his widow and his sister, Mrs Margaret Brady, for much biographical information, and to Professor Bernard Pagel who has provided an appreciation of his work on stellar energy generation. C.A.M.)