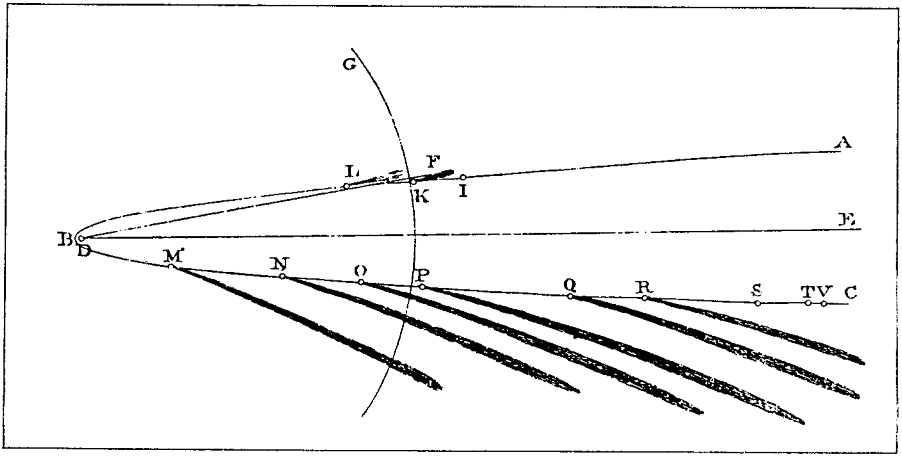
THE INSTITUTE OF PHYSICS
HISTORY OF PHYSICS GROUP

NEWSLETTER NO.6
AUTUMN 1992



GRAVITATION CONFERENCE - UNIVERSITY OF BIRMINGHAM
THE FIRM THAT MEASURED THE WORLD

EDITORIAL

There has been some delay since the appearance of the last newsletter partly due to inertial mass problems, time dilation and entropy. However these problems have been resolved and here is the resultant.

A variety of entries have been chosen and it is hoped that members would like to contribute items so that the newsletter is both reflective of the member's interests and stimulating to historical awareness and study.

There are sections on conference lectures, items from the press, guest articles and future meetings. If you know of any amusing incident or story connected with scientists or their work please send it in for possible inclusion. If you come across any interesting news cutting, have an interest in any physicist, experiment or period of physics then please send your contribution to me. It is your newsletter.

I would like to take this opportunity of thanking Peter Tyson on his superb organisation of the Gravitation Conference. The forethought and care with which he attended to the myriad of details enabled the event to run as smoothly and with as much exactitude as one of Harrison's Chronometers. He richly deserved the warm thanks extended to him by the participants for bringing about such an enjoyable and stimulating day.

HISTORY OF PHYSICS GROUP COMMITTEE MEMBERS

CHAIRMAN: Professor Sir Brian Pippard, F.R.S.

HON. SECRETARY: Dr. A.Q. Morton, The Science Museum, London, SW7 2DD.

NEWSLETTER EDITOR: Mr. R.R. Joyce, 163 Dudley Road, Upper Gornal, Dudley, W. Midlands, DY3 1TD.

OTHER MEMBERS:

Mr. D.Hooper	Mr. P. Rowlands
Mr. S. Leadstone	Mr. P. Tyson
Dr. J. J. Roche	Mrs. R. Williamson

DISCLAIMER

The IOP History of Physics Group Newsletter expresses the views of the Editor or of the named contributers, and not necessarily those of the Group nor of the Institute of Physics as a whole. While every effort is made to ensure accuracy, information must be checked before use is made of it which could involve financial or other loss. The Editor would like to be told of any errors as soon as they are noted please.

"THE HISTORY OF GRAVITATION"

UNIVERSITY OF BIRMINGHAM 26 OCT. 1991

This meeting was inspired by the centenary of Poynting's important determination of G and kindly hosted by the Dept. of Physics at the University, where there are still tangible reminders of the professor and his work. Speakers covered the study of gravitation from the times of Newton to those of Einstein and considered aspects ranging from the contribution of non-Euclidean geometry to the design of apparatus for measuring g far from the comfort of the laboratory.

Morning sessions were introduced by Goronwy Tudor Jones of the University, who has an interest in the history of Physics in general and has written on Priestley in particular. David Hughes, appropriately an old boy of the Department himself, started by describing the nature and fruits of the relationship between Newton and Halley. He was followed by Anita McConnell, whose graphic account of the thoroughness of experimenters around and under the Earth gave a whole new Perspective to the term 'in the field'. By contrast, Ivor Grattan-Guinness then spoke of Laplace's work with some interesting insights into the theory contained in the monumental, but difficult, 'Méchanique Céleste'.*

The lunch break allowed visitors to browse in a small exhibition which included exhibits from the NPL, where Poynting's apparatus is still occasionally used, small items of his which remain at Birmingham and material from the Whipple Museum.

Proceedings were reopened by Bill Burcham, now retired from his post as Professor of Physics at the University, but clearly as enthusiastic as ever. He first introduced Isobel Falconer (whose researches also include Lodge.) She spoke of Prof. Poynting in the building which still houses the spheres of his celebrated experiment and conceals the base built for it...The final speaker of the day was Clive Kilmister, who described Einstein's development of the theory of General Relativity, starting with the latter's reservations on theories implying that gravitation would depend on the reference frame, and ending with the intruiging idea that what finally evolved had features in common with Aristotle's Physics!

The day ended with a plenary session in which discussion ranged freely over topics included in, but also inspired by, the talks. The eclipse expedition of 1919 was a case in point, uniting as it did a German and an English scientist immediately after the Great War. It was a sobering thought that an error of 30% was considered quite reasonable such was the 'will to believe' at the time, and the question was asked what the conclusion might have been had the expedition taken place some years earlier, as originally planned, when theory would have yielded only half the value for the bending of the light...Other questions included the origins of the central force concept and of the symbol G. Laplace had, in fact, assigned the constant the value 1 in his treatment, at a time of considerable confusion in the area of units.

As regards the motions of planets, it is interesting to note that vortex mechanics predicted that they would orbit the sun in the same direction, but the succeeding Newtonian theory did not...One was left with the impression that there would be no shortage of questions for discussion at future meetings.

* Ivor Grattan-Guiness tells us that a set of Méchanique Céleste which the author gave to Berthollet is in the Turner Collection at Keele.

DR. DAVID W. HUGHES

HALLEY AND NEWTON, COMETS AND GRAVITATION

Newton developed the theory of gravitation in the late 17th century and the honour is solely his. But Halley's contribution must not be underestimated. Halley oversaw the publication of the theory in the *Principia* and also used the theory to predict the return of "his" comet. The success of this prediction not only helped popularize gravitational theory but also proved that gravitational forces applied to elliptical as well as circular orbits and extended to the very edge of the solar system. Whilst Newton was not a man who readily formed friendships it is clear that Halley and Newton had a considerable personal regard for each other.

They met for the first time around 1682 when Halley went to Cambridge to talk to Newton about comets. They stayed friends until Newton's death in 1727. Halley regarded himself as Newton's lieutenant and always stood in awe of the shy genius who was 14 years his elder.

Halley's scientific achievements have been underestimated due to his close temporal proximity of Newton. Comets brought them together. Halley was disillusioned by his complete inability to calculate the orbit of the comet of 1680 and was seemingly amazed by Newton's solution and the *Principia* in which the geometrical method of obtaining the majority of the orbital parameters was clearly set out.

Drawing on Kepler's three laws, many scientists in the mid 17th century had speculated on the exact form of the law of attraction between massive bodies. The inverse square relationship seemed the most likely but no one could prove it. Cometary orbits were a complete mystery at that time. Kepler had them moving along straight lines, Hevelius chose slightly bent curves but to no avail. Cometary periodicity was thought to be probable but again no one could prove it. The reasoning mainly rested on a teleological and astrological footing. Halley's Comet appeared in 1682. Two years later Newton informed Halley that comets move on parabolic or elliptical orbits and that the inverse square law predicted just that. Newton only calculated the orbit of one comet, that of 1680. He had, however, collected together all the accurate observations of cometary positions from the past, and he happily passed this information on to Halley who had kindly offered to calculate cometary orbits for him. Eventually, after many months of effort, Halley calculated the orbits of 23 comets. These, together with the orbit of the comet of 1680, were published in 1705 in his *Astronomicae Cometicae Synopsis*. Halley's list again only contained five of the six cometary orbital parameters, the eccentricity having been assumed to be unity. By 1696 Halley had convinced himself that the comet of 1682, a comet that he had observed from Islington, was the same as that of 1607 and 1531. Not only did he prove that this comet was periodic but he also predicted that it would return in 1758/59. And return it did thus underlining the universality of Newtonian gravitation.

Halley's second foray into astronomical gravitation concerned the relationship between the solar mass and the Earth-Sun distance. Newton had noted that the ratio between the solar and Earth masses was equal to the product of the cube of the ratio between the Earth-Sun and the Earth-Moon distance and the square of the ratio between the length of the month and the year. Due to the uncertainty in the known value of the Earth-Sun distance Newton had had to increase his estimate of the solar mass by a factor of eight between the first and second edition of the *Principia*. Halley's observations of the transit of Mercury across the solar disc inspired him to suggest that the transits of Venus could be used to provide an accurate value for the astronomical unit.

Much is still to be learnt about the relationship between Halley and Newton. Both were consummate scientists, polymaths and professors. But Halley, the naval captain, Astronomer Royal, family man, wit, and bon-viveur was in every way the forerunner of a modern scientist. Newton was a shy, virgin who clearly had difficulty relating to people, even though he became master of the mint, a member of parliament and President of the Royal Society. Newton was an old fashioned mystical scientist, in essence being the last of the Magi.

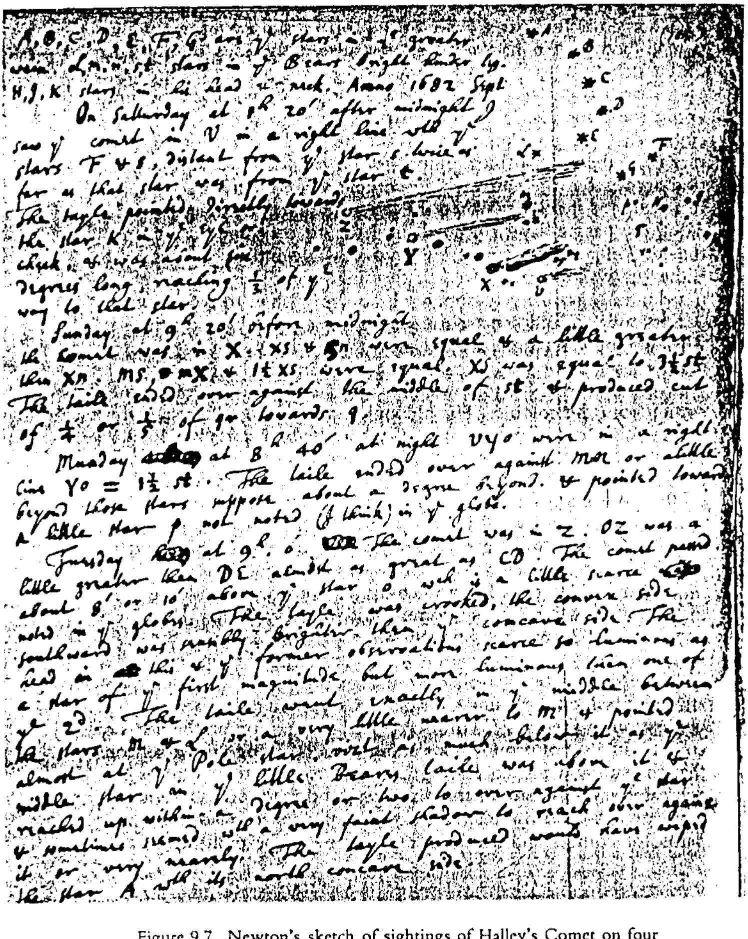


Figure 9.7. Newton's sketch of sightings of Halley's Comet on four successive nights in September 1682. (Courtesy of the Syndics of Cambridge University Library.)

DR. IVOR GRATTAN-GUINNESS

LAPLACE ON CENTRAL FORCES - FROM GRAVITATION TO 'MECHANICAL PHYSICS'

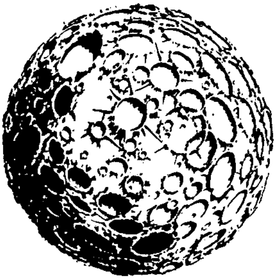
Pierre Simon Laplace (1749 - 1827) contributed to a wide range of Mathematics, Mechanics and Physics of his time, linking as he did celestial mechanics (and later heat and optics) with differential equations, series probability and statistics. Undoubtedly his greatest work was the first 4 volumes of his 'Traité de Mécanique Céleste' (1799 - 1805) (M.C.) in which he gave a mathematical model of planetary and celestial mechanics with a definitive statement on perturbation theory and equipotential surfaces. While working on the third volume, he proposed a theory which attempted to explain 'all' physical phenomena in terms of central-force interactions between 'molecules'.

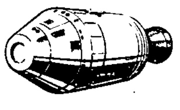
Where Laplace's work related to gravity, he was usually considering the effect, such as perturbations on planetary bodies, rather than its nature or cause. Netherthelesss, there are two passages in M.C. which do refer to the latter. The first, 'on the successive transmission of gravity', deals with the well known question of how gravity can act at a distance. M.C. is a notoriously difficult work to interpret, but Laplace's theory appeared to involve the impact of fluids which are transmiting gravity towards the attracting body. Whether this was an ether model or a caloric one is unclear - the distinction being between the nature of the fluids. He arrived at a figure of seven million times the speed of light for propogation of the fluid and a hundred million times it for that of 'gravity'. Finite propogation would clearly be crucial to his analysis of celestial affects of the gravitation.

The second discussion occurs in book sixteen of the fifth volume (1823-1825) of M.C., where Laplace discussed whether the interposition of a third body between two others would have any effect - a question considered later by Poynting among others. His treatment concluded that gravitational attraction was indeed modified, although the effect was very small. His work was used later in studying Newton's law of gravitation for 'infinite' masses.

Also relevant is Laplace's interest in the gravity pendulum. Due to the continuing attention given to the shape of the Earth (considered by Newton much earlier) and improvements in experimentation by the early 19th century, small-effects analysis became a feature. Laplace considered the effect of the wire on the pivot and this, with studies of other effects by Gauss, Poisson, Airy etc., had a profound effect on pendulum design and operation in the later years of the century.

Due to the strength and breadth of his works, Laplace had a large influence on the development of Astronomy and Physics throughout the 19th century. In addition his mathematical methods gave a strong impetus to the renaissance of Mathematics in Britain.





A McCONNELL

SWINGING THE LEAD, THE GRAVITY PENDULUM ON EXPEDITION

In 1672 the French astronomer Jean Richer noted that his clock pendulum, adjusted to beat seconds in Paris, lost time in low latitudes, an effect which he correctly ascribed to a decrease in the force of gravity. This decrease confirmed Newton's belief that the Earth was a flattened sphere. The pendulum was therefore seen as a tool with which to measure the shape of the Earth, and it was taken on expeditions for this purpose but as the early results did not match expectations they were judged to be unreliable.

The pendulum also confirmed that gravity decreased with height. In 1736 the French Academy of Science sent an astronomical expedition to the Andes to survey an arc of the meridian and resolve the argument about the overall shape of the Earth. One member of that expedition, Charles-Marie de La Condamine (1701-74), rated a pendulum at Quito on the Equator at a height of 2850 metres, and returning home along the Amazon, repeated his observations at sea level, on the Equator, where he found, as expected, a faster rate of swing corresponding to a stronger pull of gravity.

In the nineteenth century Henry Kater (1777-1835) improved the design of invariable pendulums. These were swung on survey operations in Britain and France, but despite the care taken, the results were inconclusive and it was decided to extend the operations. Edward Sabine (1788-1883) made many observations on both sides of the tropical and North Atlantic and the Arctic; in 1828-31 Henry Foster (1796-1831) made a long voyage round the South Atlantic. Strenuous efforts were made to perform these delicate scientific observations under hard physical conditions and amongst the battles for independence then disrupting the Spanish and Portuguese empires. Still the results were discordant with expected values, and eventually scientists acknowledged that the global values were frequently masked by regional geological features.

In 1854, George Airy, Astronomer Royal, compared the rates of pendulums above and below ground, and knowing the density of the intervening rocks, calculated the density of the Earth. The experiment was carried out at Harton Pit, County Durham, the vertical separation of the two pendulums being 382.82m. Airy computed the mean density of the Earth to be 6.566 ± 0.018, a far higher value than the Schiehallion survey and Baily's torsion balance measures had yielded.

From 1865 the gravity pendulums of the Great Trigonometrical Survey of India were swung in a vacuum chamber, thus avoiding the need to correct for friction of air. This greatly increased the weight and complexity of the apparatus which was transported and erected at stations along a line extending from the southern tip of India to the Himalayas. Data from the Indian gravity surveys contributed to ideas about isostasy and the Earth's interior.

The transportable pendulum frame tended to sway in rhythm with the pendulum. In the early 1880s the Austrian engineer Richard von Sterneck designed a pair of short pendulums swinging in opposition. Such compact and steady apparatus made possible the first gravity measurements in open ocean. F A Vening Meinesz, a Dutch geodesist, combined a set of short pendulums and chronograph, linked to a photographic recording system, and from 1923 he made several long oceanic voyages, discovering the strong gravity anomalies of the Java trench which we now identify as the moving edge of a tectonic plate.

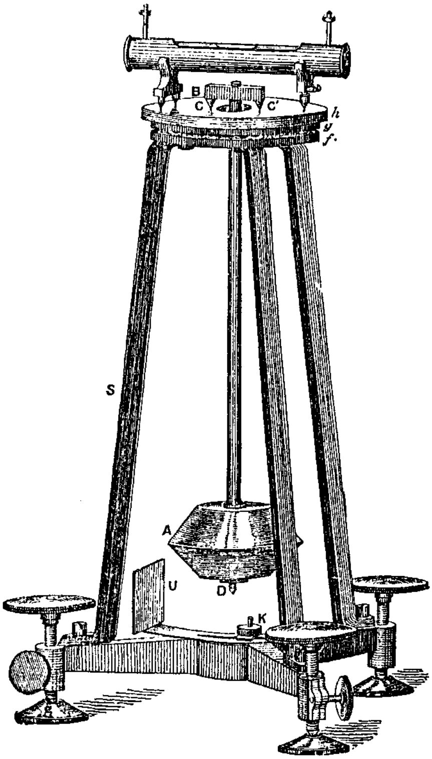


Fig 5.

Von Sterneck's Half-second Pendulums.—The labour of the determination of minute local variations in gravity was much lessened by the introduction by von Sterneck, about 1880, of half-second invariable pendulums, and his improved methods of observation have greatly increased the accuracy of relative determinations at stations connected by telegraph.

With half the time of swing the apparatus has only one-fourth the linear dimensions, and it can be made at once more steady and more portable. The size of the pendulum being thus reduced—it is about 10 inches long—it can without much trouble be placed in a chamber which can be exhausted and which can be maintained at any desired temperature. Each pendulum can therefore be made to give its own temperature and air corrections by preliminary observations. The form of the pendulum is shown in Fig. 5.

ISOBEL FALCONER

J. H. POYNTING AND THE MEAN DENSITY OF THE EARTH

One hundred years ago, Poynting announced the results of his experiment to determine the mean density of the earth. In scientific terms this was far less important than his theory of the transfer of electromagnetic enery. Yet his experiment gained him Cambridge's Adams Prize and caught the popular imagination; he was known locally as the man who weighed the earth.

John Henry Poynting was born in 1852 at Monton, near Manchester, the son of a Unitarian Minister. He was educated at Owens College Manchester, studying mainly natural philosophy and mathematics, and then at Trinity College, Cambridge where he was placed 3rd in the mathematics tripos in 1876.

After graduating, he returned to Owens College as a demonstrator. Within a year he was publishing on the statistics for drunkeness in England and Wales, and on the use of a common balance to determine the mean density of the earth. These two elements, public service (probably originating in his Unitarian upbringing) and the painstaking experimental measurement of gravitational effects, were to dominate much of his career. The gravitational experiments were moved successively to Cambridge, where Poynting obtained a fellowship in 1878, to Mason College Birmingham, where he became the first Professor of physics in 1880, and to the new University of Birmingham in 1910. Poynting was a prime mover in founding the University of Birmingham and became Dean of the Faculty of Science in 1900. In addition to the effort involved in twice planning and equipping a new physics laboratory, preparing lectures, doing research, serving various scientific societies and caring for a growing family (he married in 1880 and had 3 children), he found time to serve as a JP and as a member of the licensing committee. All this despite continual poor health, the first signs of diabetes, of which he eventually died in 1914.

Initially Poynting eschewed fundamental questions about the origins of gravity; he saw himself as part of a grand instrumental tradition of earth weighing and his determination to make a novel method work carried him through 13 years of experiments.

The novelty of Poynting's method lay in the use of a common balance, rather than a torsion balance. Methods must be devised for measuring or cancelling the attraction of all parts of the apparatus to each other, the tilting of the apparatus when the mass M is moved into position, and unpredictable temperature effects.

Finally, in 1890 Poynting obtained reliable measurements. His results were:

$G = 6.6984 \times 10^{-8}$ $\quad\quad \Delta = 5.4934$ $\quad\quad$ (c.g.s. units)

The increase in weight measured was about 1 part in 5×10^{7}, with an estimated accuracy of $\pm$ 1 %

During his 13 years of experiments Poynting's method was decisively overtaken by the torsion method, following Boys' discovery of the torsion properties of quartz fibres. He justified his publication though, '...in the case of such a constant as that of gravitation, where the results have hardly as yet begun to close in on any definite value, and where, indeed we are hardly assured of the constancy itself,it is important to have as many determinations as possible....' (1).

This is the first indication we have of Poynting considering the more fundamental problem of the nature of gravitation, which he pursued in two further experiments, those to find whether gravity differed along the optic axes of crystals (with P.L.Gray) and to find whether gravity varied with temperature (with Percy Phillips). In both cases he obtained negative results, frustrating to his search for an explanation of gravitation, for, 'This unlikeness, this independence of gravitation of any quality but mass, bars the way to any explanation of its nature.' (2). But he consoled himself with the thought that, 'We at least know something in knowing what qualities gravitation does not possess,' and when the time shall come for explanation, all these laborious, and at first sight, useless experiments will take their place in the foundation on which that explanation will be built.' (3)

(1) J.H.Poynting, 'On a determination of the mean density of the earth and the gravitation constant by means of the common balance', Phil. Trans. Roy. Soc. A 182, 1892, pp565-656.

(2) J.H.Poynting, 'Recent Studies in Gravitation', Roy. Inst. Proc. 16, 1900-1902, pp278-294

(3) ibid.

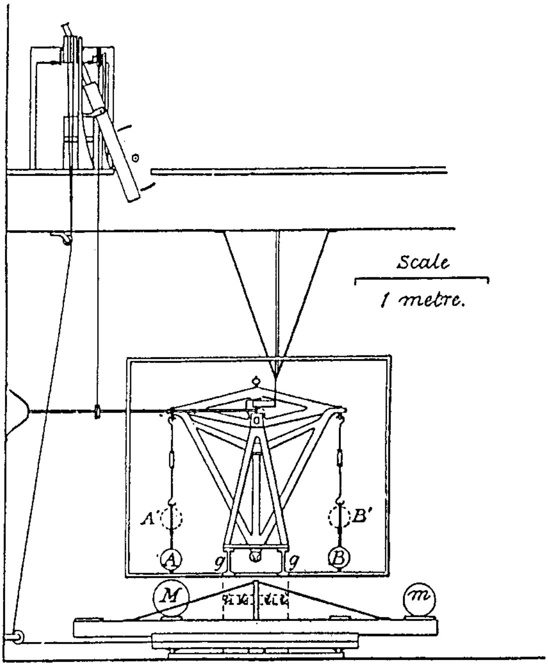


FIG. 16.—Poynting's Experiment. A B, weights, each about 50 lb., hanging from the two arms of balance. M, attracting mass on turn-table, movable so as to come under either A or B. *m*, balancing mass. A' B', second positions for A and B. In this position the attraction of M on the beam and suspending wires is the same as before, so that the difference of attraction on A and B in the two positions is due to the difference in distance of A and B only, and thus the attraction on the beam, &c., is eliminated.

THE ROAD TO GENERAL RELATIVITY AND WHERE IT LED

For all the elegance of Newton's work on the subject two hundred years earlier, there were a number of questions which still held people's interest in the theoretical side of gravitation when Special Relativity came on the scene at the start of this century. For example, although Newtonian mechanics was usually able to account for the perturbations produced by the planets on each others' orbits with great accuracy, the predicted and observed rotation of that of Mercury differed by a small but significant amount.

Special Relativity assumed the existence of preferred reference frames, the transformations between which left Newton's laws - and implicitly Maxwell's equations - invariant. Gravitation, however, was not invariant, and this was rather unsatisfactory in view of the fundamental nature and obvious success of the universal law. A theory seemed called for which made gravitation Lorentz-invariant and one was proposed by Poincaré in 1905, in a paper which formulated Special Relativity simultaneously with Einstein's, and by Nordstrom a year later.

Einstein was not satisfied with such theories since they apparently required that rotation could slow the rate at which a body would fall under gravity. Whilst, in fact, this was not an insurmountable objection, it did set him thinking and in 1907 he recognised that a transformation to an accelerating frame could abolish a uniform gravitational field. Lorentz-invariant gravitation could be appropriate only for observers in inertial frames.

Thus, Einstein felt that others were asking the wrong question but was conscious that they were pointing the way to something deeper. Fundamental to Relativity was the limiting quality of the speed of light, yet in Newtonian terms gravity produces effects at different points simultaneously.

The rotating disc problem then led him to note that invariance of tangential, but not of radial, components gave coordinates which - as Einstein himself put it around 1909 - did not have their normal metrical significance. Perhaps, he thought, there was a connection between gravitational fields and the non-Euclidean geometry which this suggested. In 1912 Einstein returned to Zurich to consult his friend Marcel Grossman and it is possible that the latter reminded him of lectures the two had attended on Gauss's theory of surfaces. A particular feature (not original to Gauss) was that a small displacement on a general surface naturally produced coordinates which did not indeed have their usual metrical meaning, and Gauss had gone on to distinguish intrinsic properties from those which would depend on the way the surface was embedded in space. Furthermore, the Italian differential geometers had generalised the concepts to n dimensions, so that Einstein could accomodate time as well as three spatial coordinates.

Starting with the geometric picture of Special Relativity and using an accelerated reference frame yielded terms which might correspond to gravitation. Einstein realised that the transformation gave merely a different description of the same situation, but around 1912 he considered reversing the argument and concluded that the extent to which an accelerated frame could abolish gravitation at <u>two</u> points was linked closely to measures of the curvature of the surface. Gravitation, of course, starts with particles and locally, in an accelerated frame, these could move in 'straight lines' - the geodesics of the 4-dimensional geometry.

It remained to connect the fields with their sources. Laplace had already produced equations involving a gravitational potential, and Poisson one which actually included the constant of gravitation. The final step along the road was to link the geometric surface parameters with the potential. Einstein achieved this, and published equations in 1915 (as did Hilbert independently) which at last gave accurate predictions on the orbit of Mercury.

This led eventually to a theory from which gravitation is effectively absent - things move in the straightest paths they can in the world in which they find themselves. So, perhaps the road leads us in a big circle back to Aristotle...

FROM THE PRESS

Now it can be told: British scientists beat Galileo by 33 years

By Adrian Berry
Science Correspondent

THE FIRST star-gazing telescope was invented by two British scientists during the reign of Queen Elizabeth I, more than 30 years earlier than hitherto believed, a scientific historian said last night.

The discovery was probably kept secret for military reasons — "the 16th century equivalent to a D-notice" — said Mr Colin Ronan in his presidential address to the British Astronomical Association.

The two inventors, who dabbled in many branches of sciences, were Leonard Digges, who died in 1571, and his son Thomas, who died in 1595. Leonard worked out the principles of the reflecting telescope and Thomas later used it to observe stars invisible to the naked eye.

The proof of this, Mr Ronan said, was a diagram that Thomas Digges drew in 1576 showing planetary orbits round the Sun as described by Copernicus 40 years before, surrounded by pictures of what he called "this orbe of stares fixed infinitely ... with perpetuall shininge glorious lightes innumerable".

A perfit description of the Cælestiall Orbes, *according to the most auncient doctrine of the Pythagoreans, &c.*

How Thomas Digges introduced his 1576 diagram of the planetary orbits *(see right)*

Mr Ronan said: "This was what Galileo saw 33 years later when he first looked at the stars through the telescope made by the Dutch lens maker Hans Lipperhey. It was always believed until now that Lipperhey made the first practical telescope."

He suggested that the Diggeses' invention was kept secret because it was a means of detecting hostile Spanish ships. "If the Spaniards had known we possessed such instruments, they could have changed the shapes of their sails."

At the time Thomas Digges first used his telescope, there was extreme nervousness in England about a Spanish invasion, and 12 years later the Spanish Armada did attack.

Because of this fear, Thomas's book containing the illustration on the right was never published. Mr Ronan tracked down part of the manuscript in the British Library.

Lipperhey's telescope was also kept secret for a time by the Dutch military authorities, who were also at war with Spain.

Another reason why the Diggeses' achievement had been ignored by scholars, Mr Ronan said, was the belief of Alexandre Koyré, the modern astronomical historian, that Thomas was talking about a "theological heaven", not an actual astronomical sky.

Thomas Digges also said his telescope enabled him to see far-off objects "as plainly as if you were corporally present, although it be distante from you as farre as eye can discrye".

Mr Patrick Moore, the astronomer, said yesterday that Mr Ronan had made an "extremely exciting discovery which deserves to be taken seriously". Last year, Mr Ronan had a 15-mile wide asteroid named after him by the International Astronomical Union in honour of his scientific books.

Digges's telescope had essentially the same design as many modern telescopes that weigh hundreds of tons. It was a "Newtonian reflector", the "first really successful instrument" and the the type supposedly first used by Isaac Newton and his colleagues a century later.

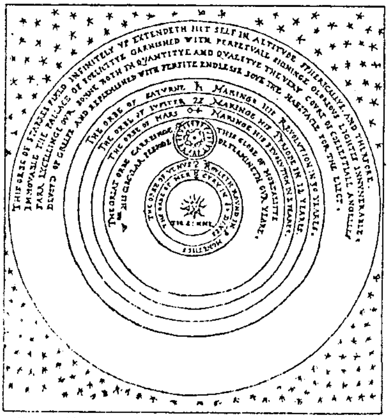
In a reflector, the eyepiece is at the side of the instrument, collecting light by means of a mirror. But a "refractor", the type invented by Lipperhey and used by Galileo, contains no mirrors, and the observer looks through one end.

"Both the Digges were highly practical mathematicians and navigators," Mr Ronan said.

In Bloody Mary's reign, Leonard Digges was condemned to death for taking part in an uprising to protest at the Queen's marriage to King Philip II of Spain. He was pardoned when Elizabeth came to the throne.

Thomas Digges was elected MP for Wallingford in 1572 and later MP for Southampton. He was also made overseer for the repair and re-fortification of Dover harbour. He fought in the Dutch wars against Spain with the rank of "muster-master-general of the English forces".

According to the Victorian scholar James Halliwell, "Tomas Digges ranks among the first mathematicians of the 16th century".



Banned by an Elizabethan version of the D notice?

Masters of the universe

1992 is the year of astronomers. **Allan Chapman** considers seven key anniversaries

ONE might think that after the double anniversaries of Babbage and Faraday in 1991 scientific commemorations would recede for a while. Yet 1992 sees no fewer than seven anniversaries in astronomy alone, with three births and four deaths; a Frenchman, an Italian and five Englishmen. Each helped to lay the foundations of our knowledge of how planets move in the solar system, while most of them lived colourful and sometimes controversial lives.

The French are making a big thing about Pierre Gassendi, who was born on January 22, 1592. The museum at Digne is holding a summer-long celebration to mark the town's most illustrious scientific figure, for while Gassendi was not born in Digne, he was an academic and ecclesiastical dignitary there for most of his life. He was one of the first great advocates of the atomic theory of matter, arguing that all substances and motions in nature derived from atoms.

Though a churchman, he searched for evidence of the Earth's motion around the Sun, in accordance with the ideas of Copernicus. In 1631 he correctly predicted and observed the first known passage — or transit — of Mercury across the Sun's disc. This led to great improvements in our knowledge of solar system dynamics and added weight to Kepler's theory that the planets move in elliptical, not circular, orbits around the Sun.

Gassendi lived a relatively quiet life. When Galileo died, on January 8, 1642, however, one of the most influential lives in the history of astronomy drew to an end. People today can empathise with Galileo; his apparent concern for academic freedom has a modern ring, along with his skilful use of the media to get his ideas across to lay society; he was a master of confrontation politics and knew all the tricks of how to vilify the opposition.

At the age of 45 Galileo was a frustrated Paduan mathematician, struggling to maintain a collection of legitimate and illegitimate dependants on a small academic stipend. But in January 1610 he turned the newly-invented telescope to the skies and changed not only his life, but the subsequent history of science. The discovery of mountains on the Moon, the phases of Venus, and Jupiter's four orbiting satellites dramatically brought home to him that the heavens were not the same as the ancients taught. Galileo was able to substantiate Copernicus's theory that the Earth moved around the Sun; his earlier work on oscillating pendulums and rolling balls took on a coherence which linked terrestrial physics with astronomy and mathematics. By the time he was 50 Galileo was famous across Europe.

Contrary to popular belief, the Catholic Church had no specific policy on the motions of the heavens at the time and burned astronomers only if they were also theological heretics. Galileo came to be patronised by cardinals and princes, and when one of his patrons, Matteo Barbarini, became Pope Urban VIII in 1625, Galileo hoped the Church would develop a policy on astronomy that would favour the moving Earth.

But in 1632 Galileo fell out with some of his powerful clerical friends, largely on personal grounds. His trial and house arrest provides a moral tale for scientists who want to change the world too quickly. The confrontation drove the Catholic establishment into a reactionary stance which badly damaged Italian science. Yet in some ways Galileo got what he wanted, for over the last 10 years of his life, he was the most illustrious scientist in Europe.

Galileo's work laid the foundation of our knowledge of the physics of the solar system. Yet he lacked a coherent explanation of the intangible force which holds the physical universe together. Its discovery was to be the work of Sir Isaac Newton. Born on Christmas Day 1642, Newton might be forgiven any ideas of destiny entertained in later life, for it was he who gave the emerging scientific movement those laws which bound the masses, velocities and distances of all moving bodies into a comprehensible whole.

Newton never knew his father, a yeoman farmer of Woolsthorpe, Lincolnshire, for he was born an orphan. But his mother, who was the only woman, and one of the very few people to whom he was ever close, soon remarried. His clerical stepfather quickly made it clear that he wished to have little to do with Isaac.

That strange and isolated childhood in Civil War Lincolnshire left its mark. Even after studying in Cambridge, and being elected an FRS while still in his twenties, Newton never found normal human relations easy. What saved him, however, was a force of mathematical intellect and power of concentration perhaps unique in history. Familiar as he was with the works of Galileo, Gassendi and more recent astronomers, Newton first turned to planetary orbits in the mid-1660s.

During the next two decades several colleagues in the Royal Society — Robert Hooke, Christopher Wren and Edmund Halley — were to address the same problem. The Royal Observatory, founded in 1675, was also able to supply new observational data of an accuracy unknown to Galileo, though the secretive Newton rarely liked to acknowledge the fact. But by 1687, when Newton's masterpiece, Principia, was published, announcing his laws of gravitation, it was clear that even a genius of his calibre was dependent upon data of ever increasing accuracy if astronomy was to move away from speculation to demonstrable truth. Seventeenth-century astronomy needed money and patronage just as much as it does now; Principia would never have appeared had it not been badgered out of Newton and paid for by his long-suffering friend, Edmund Halley, who died 250 years ago on January 14, 1742.

Halley was one of the most colourful figures in the history of astronomy, possessing a knack for both making influential friends and turning an easy profit. Born the son of a London merchant, he became famous at the age of 22 when he completed a map of southern hemisphere stars. Over the next 64 years, he worked as a diplomat, naval officer, professor and astronomer royal. Halley's sense of humour and conviviality struck a jarring chord with some of his colleagues, who regarded japes such as giving Peter the Great a ride in a wheelbarrow after a drunken binge as unbecoming to a philosopher.

BUT Halley recognised the genius of Newton, and went on to apply gravitation to the study of cometary orbits in 1704, when he correctly predicted that the bright comet of 1682 would return in 1758. Comets were now shown to belong to the solar system, and like the planets, to follow precise laws of motion that were amenable to calculation.

Two hundred years ago, on March 7, 1792, the only child of the celebrated astronomer, William Herschel, was born. John Frederick William Herschel enjoyed a star-studded undergraduate career at Cambridge to become one of the pillars of Victorian science. An urbane, kindly and generous man, John Herschel avoided controversy and bitterness, and used his 75 years to make discoveries in half a dozen sciences. A friend of Fox Talbot, he coined the word "photography" to describe the new process of light drawing in 1840, and suggested using it to map the heavens.

Studying the motions of double stars, which rotate around each other, in the 1820s, Herschel realised that gravity was truly universal, for it acted light years away from the Sun, between the "binary" stars in deepest space.

A century ago, in January 1892, two astronomers died who were involved in one of the messiest incidents in British astronomy. In 1845 John Couch Adams (1819-1892) had applied to George Biddell Airy (1801-1892), astronomer royal, for assistance in locating the as yet unknown Neptune, for which he had calculated an orbit from disturbances upon the known planet Uranus. Adams was a young and obscure Cambridge don, and because he failed to reply to the astronomer royal's letter requesting more precise information, Neptune was discovered quite independently from Berlin in 1846, and England lost the kudos.

Posterity has blamed Airy for not following up Adams's calculations, though at the time he was unfamiliar with his work and naturally reluctant to launch a search on such seemingly flimsy figures. Besides, when Adams communicated with him, the astronomer royal was distracted: a senior observing assistant at the Royal Observatory had just been arrested for murdering his incest-child, and the backlash stunned the Observatory.

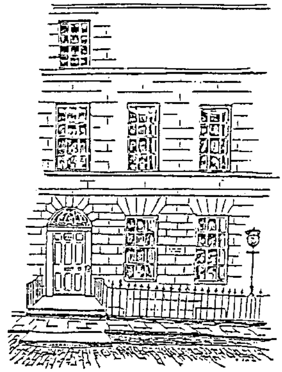
Yet Neptune's discovery not only added a new planet to the solar system, but showed that it moved exactly as predicted, in accordance with Newton's laws of gravity. It would be hard to find another single year in which more key anniversaries relating to a major sequence of discoveries had taken place than 1992, the Year of the Astronomers.

HISTORY GROUP'S FIRST SCOTTISH MEETING

On Saturday 17th April 1993 there will be a one-day meeting in Edinburgh on the life and work of Maxwell under the title

Scotland's Uncelebrated Genius:
James Clerk Maxwell 1831-1879

No special justification is needed to dedicate a one-day meeting to a physicist of Maxwell's stature. However 1993 is an especially appropriate year for this event for two reasons, one historic, the other forward-looking.



Maxwell's Birthplace
14 India Street, Edinburgh

First, 1993 is the 400th anniversary of Marischal College, Aberdeen, where Maxwell was Professor of Natural Philosophy from 1856 to 1860. Second, it is hoped that 1993 will see the culmination of the endeavours of the James Clerk Maxwell Foundation in the acquisition of Maxwell's Birthplace at 14 India Street, Edinburgh. With the kind cooperation of the Foundation, this house will be the venue for the Meeting. In due course it is planned to establish there an International Study Centre for Mathematical Sciences in honour of Maxwell.

Papers will be presented at the Meeting as follows:-

The Origins of the Clerk (Maxwell) Genius
Mr David Forfar (James Clerk Maxwell Foundation)

Maxwell's Philosophical Position
Professor Ivan Tolstoy (Biographer of Maxwell)

Maxwell's Scottish Chair:Marischal College, Aberdeen
Dr John Reid (Physics Unit, Aberdeen. Curator of the Natural Philosophy Collection at the University of Aberdeen)

Dafty, Birn and the White Horse.....the Childhood of James Clerk Maxwell
Mr Rob Fairley (Artist, and biographer of Jemima Blackburn, cousin of James Clerk Maxwell)

Maxwell and Faraday
Dr Peter Harman (Department of History, University of Lancaster. Editor of The Scientific Letters and Papers of James Clerk Maxwell)

Maxwell's Electromagnetism and Its Bearing on Modern Optics
Mr Richard Sillitto (Reader Emeritus in Physics, University of Edinburgh)

The Origins of Statistical Physics
Professor Sir Brian Pippard (Emeritus Professor of Physics, University of Cambridge)

The Meeting will be part of the Edinburgh International Science Festival and as such will be widely publicised. Because of this, and the limited audience capacity of the venue, early application is strongly advised. Application from IoP members received before 31 December 1992 will be given priority. Registration forms are available from: Stuart Leadstone, "Hallyards", South Deeside Road, Banchory, Kincardineshire, AB31 3HX.

CORRESPONDENCE

FROM GERHARD C. CADEE

Brownian emotion

SIR — Recently, in an abstract[1], Daniel H. Deutsch has argued that Robert Brown[2,3] could not have seen the random motion of small particles, later called brownian motion. Deutsch's main arguments are that Brown's system was too noisy, that he did not use coverslips (not yet invented), that his particles were too large (for example pollen grains), too light or too heavy, and that a proper achromatic microscope had not yet been invented. Deutsch says that to see real brownian motion in water at magnifications of 350× requires particles of approximately 1 micrometre and a rigid system free from vibration and evapdration.

To learn what Brown really saw in 1827, there are two requirements; a careful reading of Brown's publications and use of his (mainly single lens) microscopes. Both courses have been followed by Brian Ford[4], who gives a vivid description of Brown's findings as well as the discovery and restoration of one of Brown's microscopes, at present at the Linnean Society in London. It is not clear that Deutsch used these methods. If he had read Brown's papers more thoroughly, he would have noted that Brown did not describe the movements of pollen grains, which indeed are too large for Brownian motion, but described movements of particles *inside* pollen grains (see also the title of his paper). Brown estimate the size of these particles as 1/15,000 to 1/20,000 of an inch (1.7–1.3 μm). Later, he added that, using other single lens microscopes as well as the best achromatic compound microscopes available, he could see movements of even smaller particles (down to 1/30,000 of an inch = 0.85 μm).

A careful reading of Brown's observations refutes most of Deutsch's arguments. The particles were not too large, but of the required size of around 1 μm. Brown makes sure that the motions were not due to currents in the fluid nor to its gradual evaporation, a problem he was well aware of.

To diminish currents due to evaporation, Brown even immersed small droplets of water, containing his microscopic particles, in almond oil. The 'brownian' motion remained visible. He also mentions that, in some grasses, the membrane of the pollen was so transparent that motion of the particles could be seen inside the intact pollen grains, where currents or evaporation can be excluded as a cause of the movements observed. Our conclusion, therefore, must be that Brown did see real Brownian motion.

GERHARD C. CADÉE
Netherlands Institute for Sea Research, PO Box 59, 1790 AB Texel, The Netherlands

1. Deutsch, D.H. *Bull. Amer. Phys. Soc.* **36**, 1374 (1991).
2. Brown, R. *A brief account of microscopical observations made in the months of June, July and August, 1827, on the particles contained in the pollen of plants and the general existence of active molecules* (printed privately, London, 1828).
3. Brown, R. *Additional remarks on active molecules* (printed privately, London, 1829). (Both papers reprinted in *The Miscellaneous Botanical Works of Robert Brown* (ed. Bennett, J.J) **1**, 463–486 (Roy Soc. London, 1866).
4. Ford, B.J. *Single lens, the story of the simple microscope* (Harper & Row, New York, 1985).

© NATURE · VOL 354 · 21 NOVEMBER 1991

FROM DR. IVOR GRATTAN-GUINNESS

Dr. Grattan-Guinness informs us that an important study of the history of gravitation has recently been published:

'Framing Hypotheses. Conceptions of gravity in the 18th and 19th centuries' by Frans van Lunteren (1991, Utrecht University Proefschrift).

In it 'the author traces a story from Newton to Einstein, touching upon Poynting among his many stops. The tale is related more from the point of view of physics than mathematics.'

William Gilbert of Colchester

Gilbert's Magnum Opus *De Magnete* stands as the first sustained experimental investigation of a major branch of Physics and has rightly attracted attention ever since. Silvanus Thompson, a notable enthusiast, wrote in 1903 ' a man whose true greatness transcends that of Galileo or Bacon, and who is worthy to be set beside Newton or Shakespeare in the memories of his countrymen'. This is a stronger claim than most would make, but Gilbert's standing as the founder of the sciences of Magnetism and Electricity is unquestioned.

Two English translations of *De Magnete* appeared around the turn of the last century: one by Fleury Mottelay (1893, reprinted several times, most recently by Dover in 1958), the other by the Gilbert Club leading light Thompson (1901, reissued 1958). Neither is too easy to track down but at least the book is accessible to those of us who can't read Latin any more. A good brief introduction is given in the article by Suzanne Kelly in the Dictionary of Scientific Biography. A modern physicist approaching De Magnete is immediately impressed by the scope of the work, the carefully devised experiments and the clarity with which they are described. Thus the nature of terrestrial magnetism is established, largely with model experiments on the terrella, a piece of loadstone (magnetite) shaped into a sphere. In one compact and brilliant section Gilbert distinguishes electrostatic from magnetic attraction. In diagrams and experiments using the magnetic *versorium*, essentially the small compass needle of the elementary laboratory, Gilbert comes close to the concept of a field of force.

Inevitably the reader who responds so readily to the experimental content of De Magnete has more difficulty with the philosophical background and discussion. Gilbert's position is explicitly anti-Aristotelean and neo-Platonist and the general framework of contemporary explanation is not very familiar to non specialists. The final Book of *De Magnete* sets out a cosmological system based on magnetic attraction, a proposal taken seriously by Kepler. The Victorian, or heroic, view appears to have been to play down this Book and to emphasise the experimental content. There is no doubt, however, that Gilbert intended to establish Magnetic Philosophy as a general framework of explanation. The weight Gilbert attached to this may be judged from his only other publication, *De Mundo*. This is in fact a compilation of other writings put together by his half brother, also William, and published nearly 50 years after his death. *De Mundo* has no experimental content; it is first a cosmology and second a meteorology, both 'contra Aristotelem'.

Historians face a major problem in studying Gilbert: a lack of primary sources. Gilbert left his instruments and mineral collection to the Royal College of Physicians, of which he was ultimately President, but these did not survive the Great Fire of London. Any Cólchester documents were presumably lost in the siege of the town during the Civil War. The essential outlines of his career are known: born Colchester 1544; graduated BA (1561), MA (1564) and MD (1569) at St John's College, Cambridge. From the mid-1570's onwards he was a physician in London, ultimately rising to become one of the Queen's physicians as well as President of the Royal College. His whereabouts between 1569 and his appearance in London are unknown although the tradition of travels in Italy grew at one time from speculation to asserted fact. Certainly *De Magnete* shows familiarity with the Italian scene and the advice to carry out experiments in electrostatics at times of low humidity is phrased ' when the atmosphere is thin and the wind is from the north, or here in England from the East', but proof is lacking.

As noted, the present-day physicist approaching *De Magnete* is immediately struck by the vigour and clarity of the experimental sections and the continuing central position of the topics investigated. Some of the preoccupations revealed in the Preface are familiar too: 'let them note the great multitude of experiments and discoveries....we have dug them up and demonstrated them with much pains and sleepless nights and great money expense.' After the initial response to the grandeur of the work a range of questions arises. It is perhaps superficial to read De Magnete without going into the framework of Natural Philosophy assumed by Gilbert and if Gilbert is so serious about his Cosmology can we disregard it? The fact that Gilbert trained and practised as a physician is surely relevant. Galileo criticised *De Magnete* for lack of mathematical rigour, perhaps another anticipation of Faraday, but on the other hand the experimental method was much better established in Medicine at the time. Anyone caught up in the pain of research funding is bound to ask how the system worked in Elizabethan England and how Gilbert operated within the system. Magnetism, of course, was of great importance in Navigation and therefore central to the concerns of the State; disinterested scientific curiosity would not be the only motivation for studying it.

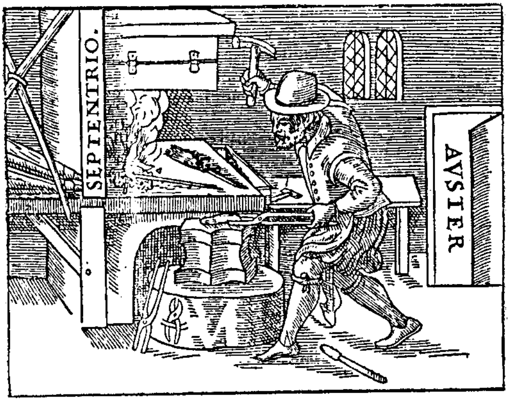
The ancient Borough of Colchester has always recognised the importance of Gilbert (always written Gilberd locally) in the history of science. Thus the 300th anniversary of Gilbert's death in 1903 was celebrated with a dinner and with the installation (at no expense to the public purse) of a painting of Gilbert at Court in the Council Chamber and a statue outside the Town Hall.

Despite the difficulty over sources we believe it is time to revive interest in the work of William Gilbert. We are therefore organising, from Friday July 9 to Sunday July 11 1993, a meeting which we hope will bring together physicists, historians of science and local historians from Colchester. This will be the Annual Meeting of the British Society for the History of Science, held jointly with the History of Physics Group. Details of the meeting are available from us. We have already received acceptances from a number of distinguished speakers. However, we have allowed time for contributed talks so the appearance of this note is also a call for papers.

Professor Ludmilla Jordanova
Department of History

Professor David Tilley
Department of Physics

University of Essex
Colchester
Essex CO4 3SQ



THE FIRM WHICH MEASURED THE WORLD

Medieval standards of length based on grains of wheat or the human foot gradually became standardised for commerce, taking shape as wood or metal bars which were held at the seat of local government. Standards thus differed from one city to the next, so that conversion tables were essential for goods traded beyond the region of production. By the 18th century this diversity was a handicap to traders, cartographers and scientists. The British Parliament and the growing body of scientists began to take an active interest in standards and the way in which they were defined and made. Many historians have examined these definitions but few have given more than a token nod to the men who made them. Yet by the 18th century these were no mere blacksmiths; John Bird and George Dollond, makers of individual standards for the Government, were craftsmen at the forefront of their profession. But the firm which probably made more standards than anyone else, and who can truly be said to have 'measured the world', was Troughton & Simms of Fleet Street, London, founded by John Troughton around 1750, continued under his nephews John and Edward Troughton, and subsequently by the Simms family.

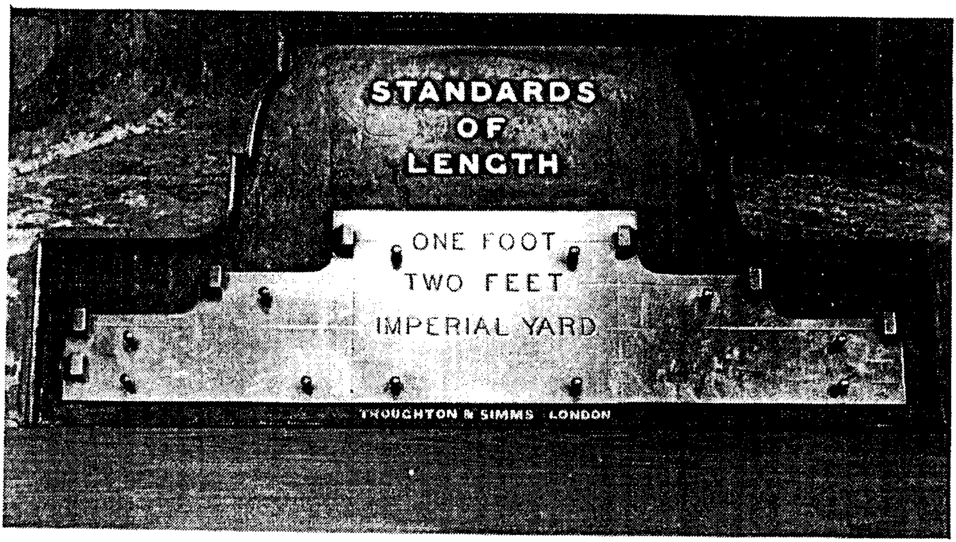
Edward Troughton (c1753-1835) is known for his wide range of fine astronomical, surveying and mathematical instruments. He also undertook to compare various foreign measures for Edward Kelly. compiler of a voluminous set of conversion tables entitled 'The Cambist'. Any maker of precision instruments, even those based on the divided circle, needs a standard of length from which to derive his fundamental measurements. Although the Exchequer held a number of so-called standard yards, dating back over the centuries, in fact they all differed in length. It therefore seemed time to find some unchanging measure, to which the yard could be related. This research was encouraged by the Royal Society and pursued by a number of scientifically-minded and suitably wealthy gentlemen, who then called on the most reputable instrument makers to provide them with delicate balances, weights and measures of capacity and of length, for the purposes of experiment. Edward Troughton made at least five standards of length, together with the necessary microscopes to compare them with other bars. The first, completed around 1792, was his own. A second went to Sir George Shuckburgh in 1796, a third to the Aberdeen City authorities around 1800 (at a cost of £93-3-0). Marc Auguste Pictet came to London in 1801 to buy a standard for use at Geneva. From his own standard, Troughton prepared an 82-inch bar to the order of F R Hassler in 1814-5, for the infant US Geodetic Survey, and towards the end of his life, probably under Simms' hand, the firm made standards for the Board of Ordnance surveys, the Danish Government and for the Royal Astronomical Society.

William Simms (1793-1860) joined Edward Troughton around 1826 and in the years up to 1862, when the firm moved to Charlton in Kent, manufacture of standards of length absorbed a considerable share of both time and space at Fleet Street. By their nature, standards were expected to endure, if not for ever, at least for many years. The length was defined at 62°F; consequently the problem was to find a durable material which, under changing temperatures, altered its length at a known rate. Earlier standards had been made of iron, which corroded, or of brass, but 'brass' could refer to any one of several mixtures, each with a different rate of expansion and all liable to corrode. Platinum did not corrode, but its rates of expansion were uncertain. Glass was tried but found wanting. Given a suitable alloy, it was the instrument-maker's task to prepare and mark out a bar of the desired length, and then to carry out a series of measurements, heating the bar to ascertain its coefficient of linear expansion.

Simms made five tubular scales between 1833 and 1835. N°1, for the Royal Astronomical Society, had been taken to the Houses of Parliament, to compare it with one made and owned by the engineer Bryan Donkin and an old yard of 1760. The comparisons were made in a Committee Room with a northern aspect, where the temperature was fairly constant. Tubular scale N°2 was made for Schumacher, for Denmark, N°3 for Struve, for Russia, N°4, six feet long, for the 'Euphrates Expedition' of 1835 which went in search of an overland route to India, and N°5 for the astronomer Francis Baily.

In 1839 comparisons were made in the cellar of Simms' premises between the 10 feet Ordnance bar and those destined for the Cape of Good Hope Observatory. In these tests Simms was assisted by members of the Royal Astronomical Society, the Board of Ordnance, Donkin's son and his own nephew, William Simms junior. The comparisons, which were repeated hour after hour, day after day, with the bars' temperatures, the atmospheric pressure and temperature all noted, must have been wearisome in the extreme, but were absolutely essential to provide a reliable measure by which entire countries would be mapped. By contrast, to check the surveying chains which he supplied in quantity to private and government order, Simms simply drove two brass plugs into the pavement outside his workshop, and marked off the exact distance of one chain, or 66 feet, between their centres.

In 1834 fire had destroyed the Houses of Parliament, where the British primary standards were stored. In due course a Commission was appointed to consider how these standards should be recreated and after years of consultation, decided that the new yard should be prepared from those in private and institutional hands. It was to be made by William Simms, supervised by a working party which included the Astronomer Royal George Biddell Airy and Baily.



Troughton and Simms standard in the Guildhall, City of London. © Anita McConnell.

Baily died in 1844, before matters had progressed far, and his place was taken by another astronomer, Richard Sheepshanks. In 1845 the engineers Maudslay & Field cast a number of gunmetal bars, varying slightly in composition, and delivered them to Fleet Street where Simms and Donkin tested their strength and rigidity by loading them to destruction. Forty bars of the best metal were then prepared as line standards. There followed the time-consuming part of the trials, when each bar in turn was put on a roller frame and lowered into a tank of water, heated by spirit lamps, so that its expansion could be measured. The scene of operations was a deep cellar under the Royal Astronomical Society's rooms in Somerset House. In these dank chilly surroundings, lit by Argand lamps, the Simmses, Bryan Donkin, Warren de la Rue, and two assistants from the Greenwich Observatory, took turns at the microscopes. Sheepshanks awarded the palm to young William Simms, saying that one of his observations was worth two by anyone else, and he proposed the young man for election to the Royal Astronomical Society in 1851. When Airy came to examine the results, he found that nearly 200,000 readings had been made in the previous ten years.

The best of the bars - that whose expansion most closely matched that of the 'lost' standard - was denominated the 'Imperial Standard'. Others were sent to major cities in the United Kingdom and Colonies, and to foreign governments for exchange with their own standards. Bars for surveying purposes were exported to Argentina, Canada, India, Russia, South Africa and elsewhere. During the 1870s, bars and studs were set up in public places for the benefit of merchants and craftsmen wishing to check their own measures. Troughton & Simms'name can still be seen on the sets in London's Trafalgar Square and the City Guildhall.

ROYAL INSTITUTION CENTRE FOR THE HISTORY OF SCIENCE & TECHNOLOGY
Telephone: 071-409 2992. Fax: 071-629 3569

RICHST RESEARCH SEMINAR

MONDAY 28 SEPTEMBER

Dr Sophie Forgan
"A fungoid assemblage of buildings" (H G Wells): Problems in the Early Development and Architecture of the Science Schools in South Kensington or *delenda est Huxleiana.*

MONDAY 26 OCTOBER

Ms Joanie Kennedy
The Radiation Delineators of Spectroscopy, 1880-1919.

MONDAY 16 NOVEMBER

Dr Robert W Smith
The Biggest Sorts of Big Science: The Space Telescope.

All seminars in the Council Room at 1630h (tea and biscuits from 1545h).

For further details contact Dr Frank A J L James.

Instrument Makers to the World

A History of Cooke, Troughton & Simms

Anita McConnell

Foreword by Hugh Scrope, Company Secretary,
Vickers Limited, 1967-84

Published by William Sessions Limited in association with the University of York

***Price: £16.00 (+£1.00 p & p U.K. or £1.75 overseas)**

ISBN 1 85072 096 7

Size: 200 × 210 mm

120 pages with 71 illustrations

Publication: April 1992

When the firm of Cooke, Troughton & Simms ceased trading in 1988, the door closed on two and a half centuries of craftsmanship, during which time scientific instruments bearing one or other of the names had seen service in every quarter of the globe.

This is the story of two firms with entirely different origins: the earliest on the scene, John Troughton, later Troughton & Simms, was established in London around 1750 as a traditional instrument-making business, and relied on extensive subcontracting until it moved to Charlton in 1865. The other, T. Cooke & Sons, was started in York in 1837 by a self-taught optical engineer who built his own factory in 1855. In 1922 the two lines merged as Cooke, Troughton & Simms of York, were subsequently taken over by Vickers, and closed down in 1988.

There is no denying that both companies merited their high status and enjoyed centuries of successful trading; none the less both were occasionally rocked by financial problems, technical disasters or general lack of harmony. The author sets the history of this major business in its technical and economic context, and sheds new light on the structure of the trade in general. The information has been drawn from the company's own archives housed in the University of York, and from published sources and manuscript material from many countries, and it is supplemented by numerous illustrations, most of which have not previously been published.

Old-style company histories were often a vehicle for self-advertisement, emphasising the successful products and the sound commercial decisions whilst keeping silent on the failures. In this book, the customers, the staff and even the bank managers are allowed to speak out for themselves.

William Sessions Limited, The Ebor Press, Huntington Road, York YO3 9HS, England
Telephone: 0904 659224 Telex: 57712 Fax: 0904 644888

***Pre-publication offer price: £10.00 + postage & packing (£1.00 U.K. or £1.75 overseas.)**

Offer closes 15th April 1992

If ordering from outside the United Kingdom, please use Sterling, Bankers Draft or International Money Order expressed in Sterling.

ORDER FORM

To: William Sessions Limited, The Ebor Press, Huntington Road, York YO3 9HS, England.

CAPITALS PLEASE

Please send .... copies of **Instrument Makers to the World** @ £10.00 per copy if ordered before 15th April 1992 + £1.00 p & p (U.K.) or £1.75 p & p (overseas).

I enclose remittance for £....................

Name ....

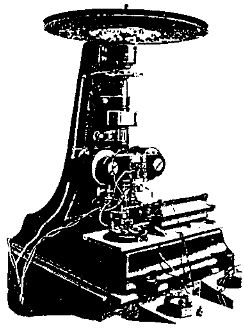
Address ....

.... Post Code ....

Date .... Signature ....

OLIVER LODGE AND THE LIVERPOOL PHYSICAL SOCIETY
BY PETER ROWLANDS

Sir Oliver Lodge, Liverpool University's first Professor of Physics, was, at the height of his career, the best-known British scientist of his day, particularly famed as a lecturer, writer and broadcaster. A vigorous and dynamic personality and a great communicator, he was a man of wide interests and prodigious energy, who had a profound influence on many of his contemporaries and, to many outside the field of science, he was its outstanding representative. Documents preserved at the University of Liverpool enable us to chart Lodge's slow rise to public fame through his connections with the Liverpool Physical Society, of which he was the founding President. These and other sources show him at once as an important figure in both local and international contexts. His scientific importance, both historical and contemporary, is related to the fact the he was a most effective link between the very different physical worlds of the nineteenth and twentieth centuries, uniting in his own person the ages of Faraday and Feynman. Emphasis is placed here on Lodge's part in the discovery of electromagnetic waves and the development of radio communications, his contributions to the foundations and developments of relativity theory, and his debates with the relativists, as well as his speculations on the aether or universal physical medium and its connections with the quantum mechanical vacuum; his most important contributions to other subjects, such as X-rays, radioactivity and electron theory, are also discussed, as are his relations with such internationally important scientists as Maxwell, Hertz, Larmor, FitzGerald, J.J. Thomson, Marconi, Lorentz, Einstein and Dirac.



'Rowlands reveals some fascinating material that links Lodge to other leading scientific figures; in particular the German physicist Heinrich Hertz.' New Scientist

'... makes a significant contribution to our knowledge of late-Victorian British physics.' Annals of Science

'....a very valuable contribution to have this study of one who was a principal actor...in the fascinating birth of twentieth-century physics. And at a very cheap price too.' British Journal for the History of Science

324pp., £15.00, paper, 1990, ISBN 0 85323 027 7
Liverpool Historical Studies No. 4

NEWTON AND THE CONCEPT OF MASS-ENERGY
by PETER ROWLANDS

Isaac Newton is well-known for his speculations in the *Opticks* on the interconversion of light and matter, but it is generally assumed that this was merely a brilliantly intuitive hypothesis, put forward without any mathematical basis. Examination of his manuscript, however, reveals that not only did Newton derive this from a mathematical argument equivalent, in principle, to the use of the equation $E = mc^2$, but that his argument provides a new insight into an anomaly in the derivation of this equation from the modern theory of relativity. The unravelling of Newton's optical drafts in the process reveals a whole host of relationships between apparently unconnected branches of physics and between ideas developed by different scientists at different periods.

40pp., £5.00, paper, 1990, ISBN 0 85323 187 7
Liverpool Historical Essays No. 4

Orders for the above title should be sent to:
Liverpool University Press, PO Box 147, Liverpool L69 3BX
Tel: 051-794 2235 Telex: 627095 UNILPL G Fax: 051-708 6502

AETHER TO RELATIVITY

Joint meeting organised by the History of Physics Group and the Liverpool Society for the History of Science and Technology

University of Liverpool 2 July 1990

With a sizeable portion of the 50 delegates coming from the University's Oliver Lodge Laboratory, it was appropriate that the meeting should begin with Bruce Hunt of the University of Texas giving an account of the famous experiment of 1891-4 in which Oliver Lodge followed up Michelson and Morley's failure to detect aether drift with a disproof of the alternative hypothesis of aether *drag*. Lodge attempted to detect a change in the interference pattern produced by light beams passing between a pair of rotating metal discs; the results, like those of Michelson and Morley, were null. This was taken as evidence either that the universal aether did not exist, or, as Lodge himself thought, that it was too perfect to be easily detected. Heavily subsidized for "the benefit of mankind" by George Holt, owner of the Blue Funnel shipping line, Lodge's work was an early example of "big science"; it was ironical, then, that it diverted him from the development of radio, work which would have been of great interest to a shipowner like George Holt.

Trevor Morris of the Department of Energy compared the views of Einstein and Lorentz, showing how Einstein moved from the assumption of a universally valid principle of relativity, via the constancy of the speed of light for all observers and the Lorentz transformations, to the fact that energy could not be transferred faster than light in a vacuum, thus implying the unique reference frame for energy transfer which was Lorentz's starting assumption. Lorentz, according to the speaker, developed exactly the same set of principles in reverse order. Einstein, however, stated that the aether was superfluous, though not necessarily nonexistent, while Lorentz was more cautious in confining the principle of relativity to the electromagnetic case; he also never completely ruled out the possibility of motion faster than light.

David Roscoe of the University of Sheffield described how Louis de Broglie had been unable to accept Bohr's Copenhagen interpretation of quantum mechanics and how his view that energy must exist as a real wave and not as a probability distribution had excluded him from the French Académie until 1988. De Broglie needed an aether and his student Vigier worked with Yukawa looking for ways to prove the aether's existence, eventually settling on a *relativistic* aether, proposed by Dirac in 1951, which could not be excluded by the usual arguments. He then joined forces with the astronomer Pecker to apply this aether to the tired light explanation of cosmological redshift. Roscoe himself thought that the Dirac aether, acting as a radiator with a random variable velocity distribution, could be shown to follow logically from a mathematical definition of rest mass.

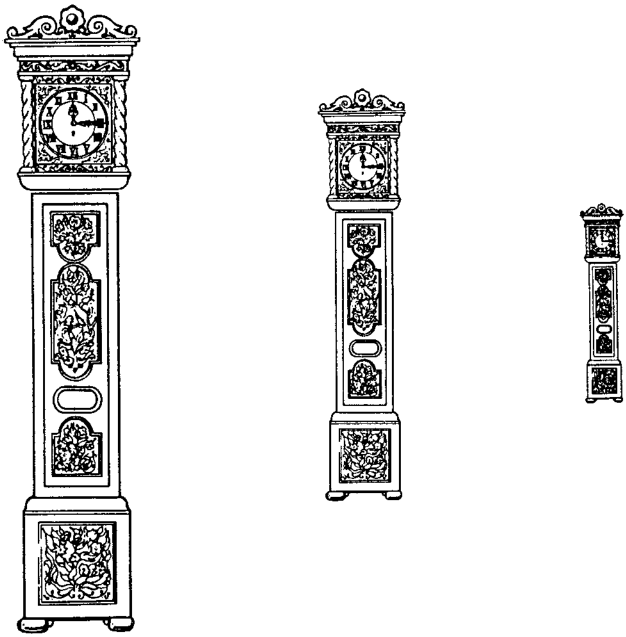
Delegates were left guessing till the last moment whether Sir Oliver Lodge was to make a personal appearance at 12.15. All were greatly intrigued, however, by the 56-year-old video in which Lodge, at the age of 83, provided a most eloquent summary of the basic themes of the morning session. During the interval there was an opportunity to visit the excellently arranged exhibition organised by David Edwards, showing apparatus and photographs relevant to the work of Lodge and his successors at Liverpool.

Michael Duffy of Sunderland Polytechnic then reviewed the whole question of the aether in the twentieth century. The aether, he stressed, was a purely mental construct which in no way challenged the accepted formal structure of the theory of relativity. The Poincaré-Lorentz and Einstein-Minkowski statements of relativity were not necessarily exclusive, while such aether models as the rod-contraction clock-retardation theory of Ives did not necessarily question the geometrised approach which had been dominant since the 1930s. Mechanical *analogues* could also be devised, which were in no sense *necessary* aspects of the theories, but which could be used as *disclosure* models; one example was the vortex-sponge analogue which some people thought could provide an acceptable physical picture of the quantum.

Simon Prokhovnik of the University of New South Wales took us "From the Aether to the Universe" with a lucid account of the development of relativity through the work of Lorntz, Poincaré, Einstein and Minkowski and of cosmology up to the discovery of the microwave background radiation in 1965. A few years before this discovery, Builder had shown the need for a universal privileged reference frame in repect of which light travels. Builder's signal contribution was to demonstrate that the time dilation effect, unlike length contraction, required an ideal clock which was the same for all directions of motion. The existence of a fundamental frame, though impossible to demonstrate in 1905, could now be shown by anisotropies in the microwave background radiation detected by a moving observer. Relativity of simultaneity due to different degrees of anisotropy with respect to different reference frames led to all the recognised null consequences of relativity and added up precisely to the Lorentz transformations; the clock paradox was also explained.

Peter Rowlands

(Committee Member, IoP
History of Physics Group)



HISTORY OF PHYSICS GROUP NEWSLETTER NO. 6 - AUTUMN 1992

Contents

Acknowledgements

Frontpiece - Newton's diagram of the orbit of the 1680 comet
© Grantham Public Libraries

Newton's Sketch - from *Never at Rest - a Biography of Isaac Newton* by R S Westfall, CUP 1980. By kind permission of the Syndics of Cambridge University Library.

Von Sterneck's Pendulum - from *Textbook of Physics - Properties of Matter* by Poynting and Thompson. Charles Griffin & Co 1903. By courtesy of Edward Arnold/Hodder and Stoughton Educational.

Digges Article - by Adrian Berry © *The Daily Telegraph* 31.10.91.

Astronomer's Anniversaries - by Allan Chapman ©*The Guardian* 6.3.92.

Blacksmith - from Gilbert's *De Magnete* 1600.