HOW TO MANAGE A REVOLUTION: ISAAC NEWTON IN THE EARLY TWENTIETH CENTURY

by

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In the first half of the twentieth century, dramatic developments in physics came to be viewed as revolutionary, apparently requiring a complete overthrow of previous theories. British physicists were keen to promote quantum physics and relativity theory as exciting and new, but the rhetoric of revolution threatened science’s claim to stability and its prestigious connections with Isaac Newton. This was particularly problematic in the first decades of the twentieth century, within the broader context of political turmoil, world war, and the emergence of modernist art and literature. This article examines how physicists responded to their cultural and political environment and worked to maintain disciplinary connections with Isaac Newton, emphasizing the importance of both the old and the new. In doing so they attempted to make the physics ‘revolution’ more palatable to a British public seeking a sense of permanence in a rapidly changing world.

Keywords: physics in the early twentieth century; science and the public; modernism; Isaac Newton; scientific revolutions

‘Revolution in science. New theory of the universe. Newtonian ideas overthrown.’ These words appeared on the top right-hand corner of page 12 of The Times on 7 November 1919.¹ The article that accompanied these dramatic pronouncements discussed a meeting held at the Royal Society on the previous day, during which various scientists had debated a possible experimental verification of Einstein’s general theory of relativity. The topic was an esoteric physical theory, proposing that time and space were interdependent and relative to the motion of the observer, and was mostly incomprehensible to anybody without a considerable amount of mathematical training. But headlines such as the one above helped generate wider interest in this event, with reference to revolution and overthrow. In the wake of the Great War, which had ended almost one year before, and the earlier Russian revolutions of 1917, these words had the potential to resonate far beyond the experiences of physicists. Indeed on the opposite side of this page, a larger headline referred to ‘The Glorious Dead’, and introduced an article about the first anniversary of the Armistice that had ended World War I.² A message from King George V was printed, inviting the citizens of the British Empire to observe two minutes of silence in remembrance of those who had died in the war. The narrative constructed around Einstein’s theory also involved remembrance, because in the aftermath of a ‘revolt’ there is destruction, the desertion of those who do not fit into a new regime. In

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the case of the 1919 ‘Revolution in science’, it became apparent that the victim would be Sir Isaac Newton.

Newton’s name represented far more than simply another scientist from the past. He had come to be regarded as ‘the world’s first scientific genius’, and one to whom British physicists could lay particular claim. Newton was a national hero, but his influence extended far beyond Britain. His work was of direct relevance to physicists, but he was regarded as a founding father of ‘modern’ science. His legacy allowed physicists to frame their discipline as a foundational science, underpinning all others, with the actions and properties of all natural phenomena reduced down to Newton’s fundamental laws of mechanics. By 1919, however, much of this narrative was under question, with the emergence of new discoveries and theories that threatened to undermine the discipline’s very foundations. Whereas the late-nineteenth-century discoveries of X-rays, radioactivity and subatomic particles had been interpreted within existing frameworks, quantum physics and relativity theory posed a more serious challenge. The category of ‘modern’ physics was emerging, and coming to be partly characterized not by its continuation of Newton’s work but by its departure from it. Physicists were in danger of losing their close connection with this hero of science. And the loss of Newton was representative of a much larger problem, concerning the relationship of modern physics to past theories. If modern physicists had indeed ‘overthrown’ Newton’s laws of mechanics, this had unwelcome implications regarding the stability of the discipline and its ability to produce objective knowledge. If laws that had been held as true for nearly 300 years were now shown to be false, why should anybody trust the new theories to be any more reliable? The transition from ‘classical’ to ‘modern’ thus needed to be very carefully managed if physicists were to maintain public trust in physics, and in science more generally.

This article explores how physicists in Britain took control of the public face of their ‘revolution’, how they emphasized the success of the new while working to maintain valuable links with the old. It details how early-twentieth-century physicists saved Newton to save themselves. In 1988 Maureen McNeil proposed that, moving beyond existing Newton reception studies, historians should explore the wider context, with the aim of ‘understanding the active creative process whereby cultural meanings are generated about who Newton was, why he matters and what he has come to signify’. However, although eighteenth and nineteenth century appropriations of Newton have been studied in depth, his role in the twentieth century has been only briefly touched upon. This article asks how Newton was reinterpreted in the context of a period of wide cultural and scientific revolution, during which his relevance and contributions to modern science were under question. As the foundations of physics appeared to be crumbling around them, how did British scientists use Newton to maintain public trust in science? In answering this question, I consider contemporary experiences of a scientific revolution, exploring how the early-twentieth-century ‘revolution’ in physics was created, manipulated and employed by its practitioners and audiences. Moving beyond the problem of determining whether there has ever been such a thing as a scientific revolution, I instead focus on the rhetoric of revolution, and its impact on the reception of scientific change.

I begin by considering the context of revolution in early-twentieth-century Britain, situating the public and professional reception of modern physics within a wider cultural landscape. I then analyse how certain physicists responded to the reports of revolution that surrounded an attempt in 1919 to test general relativity theory, before considering
later efforts to write the history of physics in a way that connected the past to the present. I look at the physicists Arthur Stanley Eddington, James Jeans, James Rice and Oliver Lodge, the astronomer A. C. D. Crommelin and the writer J. W. N. Sullivan. I reveal the considerable effort and multiple techniques used by early-twentieth-century physicists to maintain valuable links with their idol, and the effect this had on how the discipline came to be defined.

**MODERN PHYSICS AND THE ‘SPIRIT OF REVOLUTION’**

In 1911 a group of prestigious physicists gathered in Brussels to discuss the future of their discipline. At this inaugural Solvay Congress, themed around the topic of radiation, Max Planck gave an address that, for those present, cemented a new quantum-focused definition of modern physics and a corresponding classical physics.\(^{11}\) Although Planck’s words had limited reach, they were evidence of a recurring preoccupation among physicists, concerning dramatic shifts in their discipline and the relationship between the old and the new. And while these physicists began to create their own particular brand of modernism, parallel changes were occurring elsewhere. The Solvay Congress took place less than a year after December 1910, the moment famously and retrospectively pinpointed by Virginia Woolf as when ‘human character changed’. As physicists contemplated the nature of radiation, artists and writers were in the midst of corresponding modernist ‘revolutions’.

The aim of this section is not to suggest how art may have influenced science, or vice versa, but rather to explore parallels to propose that the context of cultural revolution caused changes in physics to be received in particular ways. As a result, the framework of revolution was not necessarily a welcome concept for physicists when communicating their work to wider audiences.

One important link between science and other forms of cultural and social life during the early decades of the twentieth century was the concept of discontinuity. Physicists had long conceived of nature as ultimately continuous. Even developments revealing the ever more particulate structure of the atom had not been too problematic, because such particles remained connected by the luminiferous ether, an imperceptible all-pervading substance through which light travelled. However, the development of quantum notions of energy, and the construction of physical theories of matter and energy that did not require an ethereal medium, posed a more serious challenge. The characteristic of discontinuity can also be found in modern art and literature of the period, in cubist paintings and nonlinear narratives. Looking beyond the specific characteristics of the products of art, literature and science, continuity and discontinuity may also refer to the nature of intellectual change: continuity represents a smooth transition between the old and the new, the past and the future; discontinuity suggests a sudden rupture, a fragmentary break with the past and a dramatic shift in thought. We can view developments in art, literature and physics in this period as part of a broader concern about the relationship between the past and the present.\(^{12}\)

An overriding sense of discontinuous change was not exclusive to these elite intellectual worlds, and a general feeling of revolution can be seen elsewhere. An article in *The Times* in May 1912 posed the question ‘Revolution or Reform?’, declaring: ‘ Strikes, Socialism, Syndicalism, Federalism, Devolution, Disestablishment—pregnant signs of the times and their unrest—are the leading subjects of the reviews published in the merry month of May.’\(^{13}\) In Britain, David Lloyd George’s ‘People’s Budget’ of 1909, which used taxes to
redistribute wealth from the very rich to the very poor, had faced vehement opposition. The House of Lords vetoed it, and the Liberals used the subsequent election to fight for House of Lords reform. The result was a hung parliament, and the passing of the 1911 Parliament Act, removing the Lords’ veto on financial bills. For the British public, this comparatively minor political upset was accompanied by reports of revolution abroad. The Mexican Revolution began in 1910, Francisco I. Madero took power in 1911, and in early 1913 he was forced to resign and was subsequently assassinated. The Chinese revolution of 1911 saw the establishment of the Republic of China. Meanwhile, the Agadir crisis of 1911, in which Germany sent a gunboat to the Moroccan port, resulted in international tension and fear of war.

For many, this political disruption and upheaval could be seen as part of a larger trend that characterized their culture and society in the years surrounding 1913: a move towards the ‘modern’. As the rise of technology continued unabated, people’s lives seemed to be changing dramatically at unprecedented speed. This was accompanied by a preoccupation with the same issues of the place of the past that concerned writers and artists during this period. Rieger suggests that the word ‘modern’ captured a ‘widespread conviction that the historical present was first and foremost an era of profound, irreversible, and man-made change’. Many now viewed the present and future as disconnected from the past, and history became a ‘lost domain’. Europe had entered, according to many commentators, a new historical era, known as ‘modern times’. Alongside this sense of a loss of history were numerous attempts to understand how these ‘modern times’ were related to the past: had there been a ‘fundamental rupture between the present and the past’, or was the present a result of ‘continuous, incremental change’? Technology was both progressive, making certain aspects of life easier or more efficient, and destructive, of tradition. If scientists wished to make public experiences of scientific and technological change more palatable, they needed to ensure that modern developments were seen to be compatible with earlier traditions.

Such concerns over rapid change and rejection of past authorities were captured in an address by Oliver Lodge at the 1913 meeting of the British Association for the Advancement of Science in Birmingham. This was the year of Bohr’s quantum model of the atom, a theory that combined Rutherford’s planetary model with the concept of quantum energy, proposing that electrons moved in discontinuous quantum ‘jumps’. For Oliver Lodge, this additional challenge to continuity was far from welcome. Lodge, then Principal of Birmingham University, had been a key figure in the late-nineteenth-century development of wireless technology and was deeply committed to the concept of an electromagnetic ether. By the 1910s he was a well-known public figure, dedicated to the popularization of his discipline and largely responsible for keeping the ether in public discussions. At the British Association meeting, two days before a lengthy discussion on quantum radiation, Lodge delivered a 90-minute defence of continuity. He criticized a move away from continuity and towards discontinuity, the ‘irresistible impulse to atomise everything’, locating this not just in physics but also in biology with the emergence of Mendelian heredity. Lodge’s talk also implicitly called up the broader meaning of continuity, in his grievance over ‘[a]ncient postulates...being pulled up from the roots’. Lodge did not see such sacrilege as inevitable, arguing instead that the latest developments in physics were not ‘so revolutionary as to overturn Newtonian Mechanics’. Lodge was very clear about the potentially destructive nature of revolution, and placed himself in direct opposition to such an approach: ‘I urge that we remain with,
or go back to, Newton. I see no reason against retaining all Newton’s laws, discarding nothing, but supplementing them in the light of further knowledge. Lodge used his position as a public scientist to advocate a ‘conservative attitude’.25

Considering Lodge’s age and commitment to many facets of Victorian physics, particularly the ether, his self-confessed conservative attitude is perhaps not unexpected. However, in many aspects of his life and career Lodge was decidedly nonconformist. He was a vocal supporter of psychical research and served as President of the Society for Psychical Research from 1901 to 1903 and again in 1932. Indeed, his 1913 continuity talk ended with a brief discussion of Lodge’s belief in continuity of life after death, and this was the focus in the majority of reports of his speech.26 Furthermore, Lodge was joined in his aversion to discontinuity by a much younger, and more recognizably ‘modern’, colleague, Samuel Bruce McLaren. Educated in Melbourne and Cambridge, McLaren was a lecturer in mathematics at the University of Birmingham from 1906 to 1913. Tied institutionally to Lodge, McLaren also seems to have shared some philosophical views with his colleague.27 In 1911 he wrote excitedly to his parents in Australia after being invited by Lodge to a dinner at which the French philosopher Henri Bergson would be present.28 Bergson, then very much in vogue in English high society, was also an advocate of continuity, which played an important role in his concept of time.29 However, McLaren was also a keen follower of developments in ‘modern’ physics, and he had formed a friendship with Niels Bohr during the Danish physicist’s visit to England.30 And yet in a 1913 article published in Philosophical Magazine (a journal edited by Lodge), McLaren accused ‘Einstein’s idea of the Quantum’ of being ‘destructive of the continuous medium and all that was built upon it in the nineteenth century’.31 He related this destruction to matters external to physics, declaring that ‘the unrest of our time has invaded even the world of Physics, where scarcely one of the principles long accepted as fundamental passes unchallenged by all.’ McLaren explicitly placed physics within a broader ‘spirit of revolution’.32

In the context of wider cultural shifts, discussions about atomic physics were often about much more than the technical details of opposing theories. As McLaren made clear, one could not separate quantum physics from the surrounding ‘spirit of revolution’. Like artists and writers, scientists, too, needed to be careful about rejecting past heroes and approaches. Indeed, as the next section will explore, this was perhaps a more damaging problem in science, which was supposed to be progressive, incrementally building up knowledge. A challenge to past authority in science became a challenge to science itself.

‘Revolution in science’: negotiating the consequences of the 1919 eclipse expedition

On 28 July 1914, war broke out in Europe. For many British physicists this resulted in their scientific work being directed towards practical wartime needs, including X-ray and wireless work.33 But a deeper conceptual challenge was also under way, as Einstein published his theory of general relativity in 1916. General relativity was an extension of Einstein’s earlier theory (now coming to be labelled special relativity) to encompass gravitation. The law seemed to explain a long-standing discrepancy between theory and observation with regard to the orbit of Mercury, which was more accurately described by Einstein’s general theory than by Newton’s laws.
With the end of the war providing opportunities for scientists to again collaborate across international borders, it became possible to test a second prediction of Einstein’s, that the Sun’s gravitational field should deflect the light from neighbouring stars. Although Newton’s laws also predicted this, Einstein’s value of deflection was roughly twice the amount. As a result of the brightness of the Sun, observations needed to be taken during an eclipse, and with one scheduled to appear in West Africa and Brazil in May 1919, plans began for an international scientific expedition. A Joint Permanent Eclipse Committee (JPEC) was set up, with the Director of the Cambridge Observatory, Arthur Stanley Eddington, and the Astronomer Royal, Frank Dyson, at its helm. Eddington was one of the first British converts to relativity theory and eager to draw attention to, and gain support for, Einstein’s theory. He was certainly successful in this matter, and, thanks to a ‘publicity campaign’ conducted by Eddington and other members of the JPEC, the lead up to the eclipse was reported in *The Times* and framed as a crucial experiment, in which either Einstein or Newton would be victorious. Although this achieved its purpose of injecting drama and wider interest into an event concerning the verification of an abstract physical theory, the newspaper reports also had the unintended consequence of revealing the fallibility of science. In May 1919 the *Manchester Guardian* noted: ‘It is a useful reminder in this age of enlightenment that however tall and wonderful be the structures that science builds she is all but childishly ignorant still of the bases on which they are reared.’ Thus, when *The Times* published its ‘Revolution in Science’ article on 7 November 1919, and several other papers followed suit, such an interpretation of Einstein’s ‘victory’ over Newton was a concern for many physicists.

This announcement was indeed followed by a certain amount of ‘damage control’, as physicists and astronomers worked to assure a public audience that physics, and science, remained connected to Newton and thus stable and reliable. Writing in *Contemporary Review* in late November, Eddington referred to a number of hyperbolic headlines from earlier that month: ‘REVOLUTION in Science—Newton and Euclid dethroned—Bending of Light—the Fourth Dimension—Warping of Space!’ He accused such judgements of being perhaps ‘too hasty’, but admitted that the ‘fundamental nature of the change has not been exaggerated’. However, he attempted to lay to rest any claims of Newton’s overthrow, arguing that Newton had in fact predicted, in his *Opticks*, that light could bend. Furthermore, he ended by declaring that it was ‘not necessary to picture scientists as prostrated by the new revelations, feeling that they have got to go back to the beginning and start again. The general course of experimental physics will not be deflected, and only here and there will theory be touched.’ Eddington was asserting that the results of the expedition had been significant, in line with the JPEC pre-eclipse publicity. However, he was also playing down references to revolution, insisting that neither Newton nor the practice of physics need be threatened by the results.

Eddington was not alone, and support for Newton came from another member of the JPEC, the astronomer A. C. D. Crommelin, who had travelled to Brazil for the eclipse. Writing for *The Observer* a mere nine days after the official announcement of the eclipse results, Crommelin discussed Einstein’s theory, and its accordance with the observed perihelion of mercury and the results of the eclipse expedition. He made sure to note that ‘the practical consequences of Einstein’s Law on astronomical calculations would be very slight’. In January 1920 he spoke to the Science Masters’ Association and informed his audience that most astronomers now believed that the gravitational aspect of Einstein’s theory had been confirmed. However, he insisted that ‘some newspapers went too far in
speaking of the Einstein theory as overthrowing the Newtonian theory’ and again remarked that ‘it would not be necessary to make new planetary tables at all’. Crommelin was carefully interpreting and promoting the results of the expedition as significant, but not revolutionary, and certainly not overtly challenging to Newton’s legacy or practical work in astronomy.

Unfortunately both Eddington and Crommelin’s careful rhetorical work was challenged by a rogue ‘classical’ physicist. At the 1920 British Association meeting, Oliver Lodge delivered a ‘Controversial note on relativity’, in which he suggested that relativists who were using the success of the equations to create a metaphysical structure that would ‘complicate the rest of the universe unduly’ should perhaps ‘be regarded as Bolsheviks and pulled up’. This comment was particularly damning for those physicists who were trying so hard to depict Einstein’s theory in terms other than revolutionary. Lodge’s comparison was a very quotable sound bite, reported in *The Guardian*, *The Daily Telegraph* and the *Daily News*. As with his 1913 attack on discontinuity, Lodge was here placing developments in physics in a broader social and political context, ascribing a deeper significance to ‘revolution’ in physics. Notably, a report of this same 1920 meeting noted the ‘malicious pleasure’ with which biologists had greeted a perceived damage to ‘the claim to exactness of the physical sciences, which was held to give them a higher rank than their own’. Such reports interpreted relativity theory as revealing the fallibility of physics, through the destruction of long-held tenets.

Although Lodge used the revolution narrative to attack certain aspects of the new physics, James Jeans referenced revolution when criticizing the old. A Cambridge-trained mathematician, Jeans was committed to a scientific method that began with certain premises, and from them deduced valid knowledge. This was in opposition to Eddington, who believed in using whatever techniques produced results, and worrying about an overarching theory later. Jeans’s philosophy was evident in a speech he delivered in 1926, as President of the Royal Astronomical Society, when presenting the Gold Medal to Einstein for his researches on relativity and the theory of gravitation. There he declared that Einstein had, in 1905, started a ‘revolution in scientific thought to which as yet we can see no end’. Although admitting that, in terms of practical results, Newton’s laws remained successful, Jeans did not use this as a reason to deny any massive overhaul. As he pointed out, although there was nothing wrong in this sense, the fact that Newton’s laws could not fit into the new, four-dimensional, reality meant that ‘there was as much wrong as the difference between truth and error, which the true man of science regards as the biggest magnitude with which he ever has to deal’. The message here was quite clear: Newton was wrong and Einstein was right.

It was not merely physicists who were involved in discussions about the changes in their discipline. The writer J. W. N. Sullivan was an enthusiastic supporter of the ‘new physics’, frequently contributing expositions of relativity theory to literary magazines such as the *Times Literary Supplement* and the *Athenaeum*. The second of these publications featured work by modernist writers such as Virginia Woolf and T. S. Eliot; it boasted Sullivan himself as co-editor, and the art editor was the champion of post-impressionism Roger Fry. In addition, Sullivan took it upon himself to tutor Aldous Huxley on the importance of recent scientific developments, and he corresponded with Eliot and the modernist poet Ezra Pound. Sullivan was interested in the implications of developments in physics for the relationship between science and the arts, and, through his connections with the literary world, was personally working to strengthen this relationship.
so, he played a part in the conflation of modern physics and other forms of cultural modernism, the ‘spirit of revolution’ criticized by McLaren.

Unlike contemporary physicists, Sullivan had no vested professional interest in the ongoing reputation of Newtonian physics. Furthermore, because he viewed science as the result of ‘general beliefs current in any particular age’, dramatic differences between the Newtonian and the Einsteinianden were surely to be expected. Sullivan was happy to refer to Einstein as having ‘completely revolutionised the thought of his time’ and to describe how ‘a large number of highly gifted men are engaged in effecting a complete revolution in our idea about the material universe’. Through Sullivan, the ‘revolution’ narrative seeped into literature: Huxley’s 1925 satire *Those barren leaves* depicted a character, based on Sullivan, celebrating a new ‘exciting age’ where ‘everything’s perfectly provisional and temporary—everything, from social institutions to what we’ve hitherto regarded as the most sacred scientific truths’. As a professional writer, Sullivan was both more prolific and generally more accessible than his scientific counterparts when it came to popular expositions of the new physics, and his influence among writers increased the spread of his interpretation. With Lodge’s ‘controversial note’, and Jeans’s discussion of truth and error also compromising Eddington and Crommelin’s efforts to build a less damaging framework, ‘revolution’ persisted and the threat to Newton remained.

**SITUATING NEWTON IN THE HISTORY OF MODERN PHYSICS**

Although Sullivan promoted ‘modern’ physics wherever possible, he also had great appreciation of Newton; indeed, he believed that the current state of change in physics presented an opportunity to examine Newton’s life and work more carefully. Writing in the *Times Literary Supplement* in 1927, the year of the bicentenary of Newton’s death, Sullivan suggested that the persistent ‘state of perpetual ecstatic admiration’ for Newton was incompatible with ‘a genuine and penetrating attempt to understand the man and his achievement’. Now, with ‘the whole Newtonian outlook on the universe’ under examination, it might be possible ‘to get this colossal figure into some sort of perspective’. For Sullivan, a separation of Newton from current physics was an opportunity for greater analysis. In later years, the economist John Maynard Keynes, after purchasing Newton’s alchemy manuscripts in 1936, also attempted such a venture, reframing him as ‘the last of the magicians’ rather than the first of the scientists. In contrast, Sullivan’s assessment linked Newton to the present: expanding on the topic in a 1938 book, he proposed that modern physics ‘departs less from the original Newtonian outlook than it does from the scientific outlook of the nineteenth century’: both Newton and twentieth-century physicists were aware of their discipline’s limitations, viewing their work as a tool of description, not explanation. However, whereas Sullivan produced a disjointed account that saw science progressing by circumventing the Victorian materialism he so despised, many physicists were instead attempting to situate Newton within a more linear narrative of physics. Through writing histories of the discipline, they explored Newton’s contribution and its relevance to the present day as part of a continuous enterprise.

*Relativity: an exposition without mathematics* was published in 1927, as part of the Benn’s Sixpenny Library series of cheap educational books authored by ‘experts’. In this instance, the expert was James Rice, associate professor of physics at the University
of Liverpool and a former grammar school master. Rice, who had received his scientific training in an environment that valued precision measurement and the development of experimental techniques, saw relativity theory as the result of increasing refinement of such practices, thus fitting neatly into a linear notion of progress. When explicitly tackling the topic of Newton, Rice played down the notion of ‘revolution’ by pointing out that Newton himself had helped mankind ‘break away from the last traces of medievalism in science and accept as “reasonable” a revolution in ideas about the universe far more catastrophic than that change in outlook to which men are being urged at present’. Thus, when compared with Newton’s work, modern physics was not really a revolution at all. Furthermore, the Newtonian scheme had already contained ‘a limited kind of relativity, known as “mechanical relativity”’, and all Einstein had done was expand this notion, building on the work of Newton. Rice made his point explicit:


Rice’s popular exposition made clear that any threat to Newton’s legacy was merely illusory. Although most early-twentieth-century physicists were trained in a similar fashion to Rice, with a focus on teaching and precision measurement, at Cambridge University the emphasis was on research and mathematics. The Cambridge-trained Eddington thus approached relativity in a very different way, as expressed in his 1927 Gifford Lecture, subsequently published in a popular, and hugely successful, book, The nature of the physical world. Eddington devoted his first chapter to a study of ‘The downfall of classical physics’, a category that he attempted to define. He proposed that classical physics included all theories and concepts that fitted into ‘the scheme of natural law developed by Newton in the Principia’. This scheme now ‘broke down’ because relativity and quantum theory were incompatible with it. However, Eddington insisted that it was ‘absurd’ to think that Newton’s scientific reputation had been ‘shattered’ by Einstein, and that to imagine that ‘Newton’s great scientific reputation is tossing up and down in these latter-day revolutions is to confuse science with omniscience’. Ultimately, Eddington argued that the nature of progress demanded the acceptance of great changes. Scientists were continually altering their outlook, exploring old phenomena from new perspectives:

Scientific discovery is like the fitting together of the pieces of a great jig-saw puzzle; a revolution of science does not mean that the pieces already arranged and interlocked have to be dispersed; it means that in fitting on fresh pieces we have had to revise our impression of what the puzzle-picture is going to be like. One day you ask the scientist how he is getting on; he replies, ‘Finely. I have very nearly finished this piece of blue sky.’ Another day you ask how the sky is progressing and are told, ‘I have added a lot more, but it was sea, not sky; there’s a boat floating on the top of it’. Perhaps next time it will have turned out to be a parasol upside down; but our friend is still enthusiastically delighted with the progress he is making.

Eddington was here denying that the revolution in physics had been destructive to the older theories, suggesting instead a process of modification. Nothing was completely
rejected, but rather repositioned in relation to newer ideas. In Eddington’s interpretation, Newton remained a fundamental part of the progress of physics.

Similar methods of linking Newton to modern physics were crucial in the year 1942, which marked the 300th anniversary of Isaac Newton’s birth. In the midst of a world war that was to emphasize the future applications of ‘modern’ physics, the Royal Society held a small event in honour of the discipline’s past. The intention was not only to celebrate the great past achievements of Newton, a former President of the Society, but to also consider the place they held in the physics of the 1940s and beyond. It was an opportunity to reframe his work in the context of ‘modern’ physics and to explore its current value. If reconciliation could not be made between ‘classical’ and ‘modern’ physics, there was the possibility that physicists might lose claim to their 300-year-old idol.

Amid discussions of Newton’s theories and experimental prowess, James Jeans was afforded the task of providing ‘some reassessment of the validity and permanence of Newton’s system, in relation to the immense advances of knowledge in our own times’. He was introduced by the President of the Royal Society, Henry Dale, who asked, ‘How is the Newtonian system affected by the quantum mechanics at opposite ends of the stupendous scale? Is it being supplemented, modified or superseded after its centuries of dominance?’68 Jeans, dismissive of Newton when addressing the Royal Astronomical Society, now took a more positive approach, addressing Dale’s questions head on. He noted that physicists of course had ‘no doubts as to [Newton’s] greatness, but we probably feel less confident in our powers to assess his ultimate position in science than we should have done fifty years ago’. Indeed, where the immediate successors of Newton had claimed ‘a quality of finality and uniqueness’ in Newton’s work, this was something ‘which we know better than claim for him to-day’.69 Jeans considered the work of Planck, Rutherford and Einstein, each representative of a different modern physics: the quantum, the nuclear, and the relativistic, respectively. He noted that they had uncovered new ‘ante-chambers’ in Newton’s ‘temple’ of knowledge, and considered its implications for how we were to remember Newton:

There are some—although mostly laymen in science—who see science primarily as something that is for ever changing. For them the science of any period is like the sand-castles that the children build on the sea-shore; the rising tide will soon wash them away, and leave the sands clear for the new array of castles which will be built the next day. Those who hold such views are led, somewhat naturally, to make such statements as that Newton is out-of-date and superseded.70

However, this was not how science worked, for ‘Science is knowledge, and the primary characteristic of knowledge is not that it is for ever changing, but that it is for ever growing.’ Jeans proposed that a more suitable metaphor than the sandcastle, which is washed away and replaced, would be a ‘vast building’ on which new floors are added and new wings constructed. This building was ‘the embodiment of scientific truth, and the truths of science are the same, no matter who discovers them’.71 Such a metaphor proposes an image of Newton not as wrong, but instead limited, uncovering some of the truth, but not all of it; and Jeans explored this in his talk.

He proposed that there were ‘three worlds’, and in each world different scientific laws applied. The ‘small-scale world of electrons and of atomic physics in general’ was governed by the laws of quantum mechanics, ‘the man-sized world’ by Newtonian
mechanics, and the ‘world of the great nebulae’ by relativity theory. Although all of these worlds were ultimately subject to the same laws, ‘factors which are all-important in one become mere insignificant corrections in the others’. Thus, Newtonian mechanics was not completely incorrect; it was rather only correct in his designated world, the only world to which he had access in the seventeenth century. His laws were ‘inadequate only with reference to the ultra-refinements of modern science’. As such, these laws were still of use in 1942. They had considerable practical utility, for the astronomer and the engineer, and ‘in the science of everyday life’.

Jeans’s lecture was, first and foremost, a defence of Newton in the face of ‘modern’ physics, a call for reconciliation between the old and the new. He was proposing a model of science as progressing through building on the work of predecessors, standing on the shoulders of giants. Nothing once perceived as valuable was to be overthrown or superseded. He was able to do so by situating ‘classical’ physics in a different world from ‘modern’ physics. In Jeans’s narrative of the progress of the discipline, Newtonian physics had not only been of benefit in the construction of modern theories, it was still in use today. Classical physics was the physics of the everyday, and if one wanted to garner information about this particular world, Newton’s path was the route to be taken.

**CONCLUSION**

Throughout the first half of the twentieth century, physicists struggled to reconcile the dramatic changes in their discipline with a heritage they hoped to protect. In doing so, they constructed definitions not just of the classical and the modern, but also of physics itself. There were multiple ways to ‘manage a revolution’, to construct a disciplinary identity that cherished both Einstein and Newton simultaneously. One option was to emphasize that the theoretical developments, although indeed profound, would not affect the day-to-day practice of physics or astronomy, which continued to follow Newtonian lines. Another was to suggest that long-established theories had themselves been viewed as revolutionary when first introduced. New ideas could be framed as supplemental, as generalizations, not replacements. Additionally, one could describe the history of physics as a linear rise in experimental precision, or a constant re-altering of perspectives. Classical and modern physics could occupy two separate worlds in which different laws applied.

All of these approaches are connected by an emphasis on progress, whether this took the form of Rice’s experimental techniques or a conceptual wing on Jeans’s metaphorical building. The notion of progress was crucial to the reputation of physics, and made the challenge of ‘modernism’ perhaps more difficult than in other disciplines. Although artists and writers also struggled with the idea of abandoning past authority, for physicists this past was more closely tied in to their present-day dominance. In destroying their foundations, they revealed their fallibility, and damaged their claim to a ‘greater’ truth, one that only scientists had access to. By constructing a narrative of progress, linking Newton to Einstein, physicists were able to hold on to their reputation. Newton’s role in the twentieth century was thus similar to that of the ether in the nineteenth century: he provided continuity. He may no longer have been the source of advances in theoretical physics, but in a period of war and revolution, of rapid change that seemed to penetrate all of culture and society, Newton was indispensable.
In this article I have treated the physics ‘revolution’ as not in the fundamental nature of the science itself, but rather in the politics of knowledge surrounding the discipline. By situating early-twentieth-century discussions about the ‘revolution’ in the broader context of their time, I have shown how they fit into, and were influenced by, contemporary issues facing a wider British public. In the midst of political turmoil, two world wars and the advance of modernist art and literature, the potential ‘overthrow’ of Newton took on greater significance. There was a considerable need for science to retain its appearance of stability, and physicists were able to do this by maintaining links with their prestigious past. The emerging categories of classical and modern physics provided a means to connect the past to the present. Responding to external developments, physicists framed these categories as separate but connected, depicting their discipline as exhilaratingly new but also comfortably old. They emphasized the importance of both the classical and the modern, finding a place for Newton in the twentieth century.

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NOTES

5 Iwan Rhys Morus, When physics became king (University of Chicago Press, 2005).
8 For an overview of early-twentieth-century popularization of science, see Peter Bowler, Science for all: the popularization of science in early twentieth-century Britain (University of Chicago Press, 2009). For theoretical approaches to science and the public, see Peter Broks, Understanding popular science (Open University Press, Milton Keynes, 2006); Roger Cooter


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For a recent and comprehensive overview of Bohr’s development of the quantum atom, and its reception, see Helge Kragh, *Niels Bohr and the quantum atom* (Oxford University Press, 2012).


23 Ibid., p. 11.

24 Ibid., p. 12.

25 Ibid., p. 44.


30 Kragh, op. cit. (note 19).


32 Ibid., p. 43.


36 Sponsel, op. cit. (note 34).


40 Ibid., p. 639.

41 Ibid., p. 643.
How to manage a revolution


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The *Athenæum* merged with the *Nation* in 1921 and *New Statesman* in 1931.


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