An Introduction to Relativity in James Joyce's *Ulysses*

A thesis presented in partial fulfillment
of the requirements for the degree of
Master of Arts
In English
At Massey University

A. E. Sanson
1999

ACKNOWLEDGEMENTS

Thanks to Professor Dick Corballis for your guidance, for your wisdom and for imparting your knowledge, writing, and editing skills over the duration of this thesis.

Thanks to Associate Professor John Needham who helped me get over the initial writer's block and encouraged me to just write; this was valuable advice.

Thanks to my wife who typed this thesis.

ABSTRACT

Unavailable to Leopold Bloom in 1904, but front page news to Joyce as he scripted *Ulysses*, Albert Einstein's relativity theories superseded Sir Isaac Newton's theories about absolute space, absolute time, laws of motion, and the universal law of gravitation during the period 1905 – 1922. The opposition between Newtonian mechanics and Einsteinian relativity was played out in the newspapers of the time and incorporated anachronistically into Joyce's novel in his characterisation of Bloom, who is not only a metempsychotic reincarnation of the ancient Greek hero Odysseus, but also a metempsychotic anticipation of the greatest scientist of the twentieth century, Albert Einstein. Musing continually on the ultimate nature of time, space, motion, light, and gravitation, Bloom verges on the brink of an Einsteinian epiphany without ever quite achieving one.

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INTRODUCTION

In the course of determining the 100 most influential people of the 20th century, *Time* magazine - after "soliciting nominations from ... editors and journalists around the world, consulting outside experts and historians, and sifting through thousands of suggestions from readers" (Isaacson 4) - chose James Joyce as the most influential writer and *Ulysses* as the century's pre-eminent literary work. Paul Gray, author of the *Time* feature and also of a Ph.D. dissertation on Joyce, observes that "Even before *Ulysses* was published, critics were comparing Joyce's breakthroughs to those of Einstein and Freud"(63). It is the connection with Einstein in particular that is explored in this thesis.

Most people know that the action of *Ulysses* takes place on one day, 16 June 1904. Stuart Gilbert adds that, "the unity of place is as thoroughgoing as that of time" (28). Yet, these two unities are honoured as much in the breach as the observance. After all, the principal character - Bloom - is a metempsychotic reincarnation of the ancient Greek hero, Odysseus. Not so well known - despite Gray's hint - is the fact that Bloom is also an anticipation of the greatest scientist of Joyce's age: Albert Einstein. Thus, ancient Greece and future Europe co-exist with contemporary Dublin in Joyce's book. Gilbert seemed to acknowledge this when he qualified his earlier remarks about unities with the observation that: "Joyce ... always aimed at being a European writer and, in his major works, linked up the local theme with wider references in Space and Time" (93).

Einstein published his special theory of relativity in 1905[1] and his general theory of relativity in 1916[2]. Both theories postdate Bloomsday itself, but were available to Joyce as he drafted *Ulysses*. Robert March has this to say about the relationship of Einstein's theories to Newton's:

> There is no quarrel between Newton and Einstein over the description of ... space-time tracks. What they disagree about is their significance. Newton

[1] The special theory of relativity is not Einstein's original name, but I use it for convenience. The original name is "*Zur Elektrodynamik bewegter Köper* [On the Electrodynamics of Moving Bodies]."
[2] The English translations came later, but I will, overall, use the dates of the original German versions.

> says that the tracks are curved by the action of a force. Einstein insists that no force is necessary: space-time itself is curved (142).

Thus, Newton's concepts are linear and Einstein's concepts are curved, non-linear. Gary Zukav writes:

> According to Einstein's ultimate vision ... a piece of matter *is* a curvature of the space-time continuum! In other words, according to Einstein's ultimate vision ... there is no such thing as "gravity" - gravity is the equivalent of acceleration, which is motion. There is no such thing as "matter" - matter is a curvature of the space-time continuum. There is not even such a thing as "energy" - energy equals mass and mass is space-time curvature (199).

There is in Joyce's *oeuvre* as a whole a movement from linear to cyclical organisation. *A Portrait of the Artist as a Young man*, from its tell-tale opening phrase "Once upon a time" to the adult Stephen's preparation to leave Dublin, exemplifies the former; *Finnegans Wake*, whose end takes us back to its beginning, the latter. *Ulysses* is the transitional text; it gradually abandons linear narration for increasingly curved and cyclical patterns.

Wyndham Lewis, in *Time and Western Man*, wrote:

> In *Ulysses* you have a deliberate display, on a grand scale, of technical virtuosity and of literary scholarship .... This torrent of matter is the einsteinian [*sic*] flux. Or (equally well) it is the duration-flux of Bergson - that is its philosophic character, at all events (102-3).

This "philosophic character", Lewis argues, is the character of a "time mind" or a "time philosophy": "I regard *Ulysses* as a *time-book*; and by that I mean that it lays its emphasis upon, by choice manipulates, and in a doctrinaire manner, the self-conscious time-sense, that has now been erected into a universal philosophy" (84). In *Finnegans Wake*, Joyce took his literary revenge on Lewis, referring to him as "windy Nous (*FW* 56.29) and "wind hound loose"(*FW* 471.21), and - swapping one dimension for another - to his book as "*Spice and Westend Woman*" (*FW* 292.61). Yet, Joyce never refuted Lewis's basic assumption: that *Ulysses* is organised along the lines of Einsteinian time theory, the "universal philosophy" of time established by the special and general theories. Of course, the cyclical pattern of time organisation in *Finnegans Wake* is even more evident than it

is in *Ulysses,* and Einstein's name is alluded to several times in the later text (e.g. *FW* 231.29, 149.28, 126.15, 152.18, 277.18, 305.6, 305.29).

Since Lewis gave the lead so early, one might have expected the discrepancies between Newton and Einstein's time theories to be a fertile field for critical research, especially since the advent of deconstruction. Yet, Udaya Kumar is typical of most deconstructionists when he states in *The Joycean Labyrinth*: *Time Repetition and Tradition*:

> The validity of Lewis's philosophical argument is indisputable. One could argue against a facile identification of the Bergsonian and the Einsteinian notions of time.... However, it is not my purpose to examine these explicitly philosophical aspects of Lewis's argument (57).

Surprisingly, the opposition between Newton's theory of absolute space and absolute time, and Einstein's general theory of relativity with its curvature of space-time seems to hold little appeal for Kumar and other deconstructionists. In the main, recent deconstructionist criticism has emphasised the play of language in *Ulysses*, and left undeconstructed its unity of place and time. Although the critics have frequently alluded to the Newton/Einstein opposition, it has never been explored in depth.

Alan J. Friedman provides an excellent review of the critical literature devoted to scientific issues in *Ulysses*:

> Several literary critics have used the terms "relativity" and "uncertainty principle" in relation to science and *Ulysses*.... Marilyn French ... claims: "Joyce clearly intended to show incertitude as operating in the cosmos as well as the world". Her examples are all the subjects of classical nineteenth-century Newtonian astronomy....
>
> Richard Kain discusses science occasionally throughout his very useful study, *Fabulous Voyager*: "The picture of modern science given in *Ulysses* is that it constitutes a new folklore of a 'believe-it-or-not' nature and that its principal appeal to modern man is as a materialistic aid to wealth or to the saving of effort". The modern science Kain is discussing is not relativity.... Kain's use of the term "relativity" in his final chapter refer each time to single measurements of time or space, with no particular meaning for Einsteinian physics.
>
> Littman and Schweighauser accurately and thoroughly examine the astronomical terms in *Ulysses*. All examples are comfortably nineteenth-century, and Littmann and Schweighuaser suggest mostly direct symbolic uses of that science.

> Wyndham Lewis, in 1927, directly claimed a relation between *Ulysses* and Einstein, but more a spiritual connection than a scientific one....
>
> Avrom Fleishman gives a different direction for searching out connections between *Ulysses* and twentieth-century science: style. Fleishman reasonably points out that the science content of *Ulysses*, set in 1904, should not directly mention Einstein's relativity, which was first published in 1905.... Although Fleishman gives one example from "Ithaca" that he claims is clearly intended to refer to Einstein's cosmology....
>
> Science as style is also the most convincing aspect of Tindall's treatment. He also sees the style as cold, to "project the inhumanity of science." Edward Watson too finds the science of "Ithaca" directed at demonstrating the objective, impersonal style of science, to be contrasted with the romantic, humanistic approach of other chapters.
>
> None of this critical material makes a strong case, at least for me, that *Ulysses* has a specific *content* connection with twentieth-century science.... I think we must wait, at least until *Finnegans Wake*... to find direct evidence of links between the two modern revolutions in science and James Joyce (201-2).

Andrzej Duszenko provides abundant evidence of the theory of relativity in the *Wake* in his article, "The Relativity Theory in *Finnegans Wake*" (*JJQ* 61-70). However, this work does not cover *Ulysses*. Still unpublished, but available May 1998 on the Internet, is a further article by Duszenko with the same title. It is not just a minor revision of the first publication, but provides completely new research on the subject of relativity theory in *Finnegans Wake*.

Thomas Jackson Rice's recent book *Joyce Chaos and Complexity* studies "the interplay of mathematics and science in the formation of James Joyce, literary artist" (xiii) but has little to say specifically about Einstein. Perhaps contemporary critics would see the links between "modern revolutions in science and James Joyce" (Friedman 202) if they were to pay more attention to the links between the former and recent developments in critical theory which, on the whole, Rice deprecates.

Joan Parisi Wilcox identifies one example of non-Euclidean geometry in the opening sentence of "Ithaca" and mentions "Reimann" (645), but makes no link to Einstein, who in fact made extensive use of Reimann's geometry in the general theory of relativity.

Apart from Fleishman's brief reference to Einsteinian cosmology in "Ithaca" (noted above), only two articles deal affirmatively with the links between *Ulysses* and

Einsteinian theory. John Hannay identifies Einstein's relative motion postulate in the movement of Bloom's crumpled paper ball in "The Throwaway of 'Wandering Rocks'". Stephen Whittaker and Francis X. Jordan find that Bloom's musing about light at *U* 4.83-86 hints at relativistic time dilation.

More negatively, M. Keith Brooker, in "Joyce, Plank, Einstein, and Heisenberg: A Relativistic Quantum Mechanical Discussion of *Ulysses*" writes:

> ... Einstein's work on relativity was published during the period 1905-1915, and the experimental verification of the General Theory of Relativity in 1919 made front page news, a fact of which Joyce was no doubt aware. It is not unlikely that Joyce's imagination was kindled by the publicity given Einstein's work ... even if he had no in-depth understanding of the theories themselves (583-4).

Similarly, Mario Salvadori and Myron Schwartzman assert:

> Joyce's knowledge of mathematics and science was relatively limited.... Despite ... his awareness of Einstein's relativity theory ... Joyce's mechanics are totally Newtonian with a strong emphasis on the importance of Newton's gravitational law" (353).

In "The Newtonian Nightmare of *Ulysses*", Alan David Perlis also cautions:

> *Ulysses* is the post-Newtonian mechanical world turned into a nightmare.... Implied in my application of the Newtonian world view is a caution against any facile argument for the novel as an "epic of relativity," or one in which an Einsteinian vision of a world bound by the limits of how we perceive it prevails (195-6).

Long before Derrida - influenced at least to some extent by Joyce - argued that words exist in a state of "incertitude", "mobility", "slippage", and "decentred freeplay" (109-12), Homer described how Telemachus confronted Proteus, "the slippery god of the sea, whose constantly changing shape enabled him ... to elude all attempts to hold and question him" (Blamires 13), until he was finally fixed and forced to give up his truth. Einstein confronted the same problem of the slippage of absolutes into relativity when he deconstructed the Newtonian concept of "absolute space and time" (Wilson 162) and substituted "the curved spacetime of general relativity" (223).

In *Ulysses* too, linear time is subjected to Protean circular patterns, often symbolised by swirls and the ebb and flow of the tide. The reader is, as the critics often remind us, confronted by wave after wave of polyglossia, whereby no single discourse is authoritative or privileged, so anything one particular character might say or do is soon undercut by a conflicting voice, point of view, differing recollection, or ridicule by the "carnivalesque" of the Arranger. In addition, time seems to be continuously shifting under the reader's feet. It is. Joyce's organisation of time is as slippery as Proteus, with constant shifts out of the present, into the past, into the future and back again.

This constant sabotage of Newtonian time by Einsteinian warpage or circular patterning is highlighted in several ways. The text virtually abandons any form of linear organisation after "Wandering Rocks", preferring increasingly circular and cyclical patterns of discourse (though "Nausicaa" is fairly linear). Moreover, there is throughout a constant vacillation between exterior, naturalistic and chronological time and interior, psychological responses to time and reworkings of that time. Most important, for my purposes, the novel's central character, Bloom, is continually on the verge of an Einsteinian epiphany, but clings obstinately to Newtonian principles. In the discussion that follows, the emphasis will be on the last of these motifs: Bloom's unwitting anticipation of Einstein's theories.

A BRIEF HISTORY

The traditional understanding of space and time is modified in Einstein's special and general theories of relativity. Since the two theories were published piecemeal in German and then translated into other languages, the cited publication dates vary somewhat, depending on which of Einstein's works the various biographers, physicists, and authors choose to quote. Beginning with the publication of "*Die Grundlage der allgemeinen Relativitätstheorie*" (Pais 524) on 20 March 1916, the general theory of relativity was Einstein's extension - to include gravitation - of the 1905 special theory, which modified our understanding of space, time, and matter relative to the speed of light. The special theory was first articulated in "On the Electrodynamics of Moving Bodies" published in *Annalen der Physik* September 1905. This article established the relativity principle of space and time. A second paper, "Does the Inertia of a Body Depend upon its Energy-Content?"[3] published on 27 November 1905, promulgated the equation, $E=mc^2$. It literally destroyed Newton's notions of space, time, matter, inertia, and mass. The two papers constitute what later became known as the special theory of relativity. Published in December 1916, "*Über die Spezielle und die Allgemein Relativistätstheorie, Gemeinverständlich*" was Einstein's "most widely known book"; it established the four-dimensional general theory of relativity but the "quadrupole formula" describing "gravitational waves," which rendered obsolete Newton's universal law of gravitation, was not published until "February 1918" (Pais 525).

Support for the general theory of relativity came from Sir Arthur Stanley Eddington's observations concerning gravitation's effect on light during the solar eclipse of 29 May 1919, which were promulgated in the Astronomer Royal's address on 6 November 1919 to a combined meeting of London's Royal Society and the Royal Astronomical Society. The next day a front-page headline in the London *Times* read: "Revolution in Science - New Theory of the Universe - Newtonian Ideas Overthrown". The 10 November headline in *The New York Times,* which read "Lights all Askew in the Heavens - Einstein Theory Triumphs" (Pais 525), marked the emergence of Einstein as a

[3] The German title for this paper is "*Ist die Trägheit eins Körper von seinnem Energiegehalt Abhängig*?"

worldwide celebrity. His later 1921 trip to America in support of international Zionism made him into a media superstar. Rising anti-Semitism in pre-Nazi Germany eventually forced Einstein to emigrate to America, where, over forty years after 1905, he saw the actual proof of his most famous formula, $E=mc^2$: the atomic bomb. At the same time that Einstein's name and theories were constantly in the media, Joyce was drafting *Ulysses* and, I contend, incorporating some of Einstein's accomplishments into the characterisation of Bloom.

NEWTON, EINSTEIN, *ULYSSES*: DEFINITIONS AND COMPARISONS

Einstein's theories are very complicated. Thus, the concepts and terms which are alluded to in some form or another in *Ulysses* require clarification so that Bloom's physics and its relationship to Einstein's physics can be understood. What follows is largely drawn straight out of a description of Einstein's theory in *The Theory of Relativity*[4] by C. Møller, a Professor of Mathematical Physics.

Einstein's special theory of relativity (1905) is special in the sense that it works only for constant and uniform linear motion and excludes gravitation and acceleration. Originally called "On the Electrodynamics of Moving Bodies", it is a theory which seeks to account for all phenomena relating to relative motion. Therefore, it amalgamates Newton's laws of motion, which apply to mechanical objects, with James Clerk Maxwell's equations, which account for the motion of electromagnetic phenomena such as light waves. It mathematically describes the instability of time, space, and mass at high relative velocities. Increasing velocity toward the absolute speed of light, *c*, causes time dilation (the clock paradox which comes up in Stephen's Hamlet theory and Bloom's musings on time in *U* 4.80-6) and the shortening of lengths (the Fitzgerald contraction[5]), and mass tends toward infinity ($E = mc^2$). So mass and energy, spatial distance and time actually all vary in relation to the absolute velocity *c*.

Newton's three laws of motion and his universal law of gravitation assume that things like mass, velocity, and force are discrete quantities which can be measured at any point in absolute time and space. Therefore, Newton's theories are founded on the notions of "absolute", "universal", and "linear" time. Colin Wilson in *The Book of Time* summarises Newton's theory as: "... the idea that time may be likened to a straight line

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[4] Unattributed page references in this chapter/section are to this book of Møller's. The cognate *Ulysses* passages, which are merely noted at this stage in the form of references to the Gabler edition as required by the *James Joyce Quarterly*, will be returned to later in the thesis.

[5] According to Nathan Spielberg, objects in motion contract in length along the line of motion, eventually shrinking to zero at the speed of light. The effect was first suggested "in 1882, [by] two physicists, G. F. Fitzgerald ... and H.A. Lorentz" and "suggested a solution to the dilemma posed by the Michelson-Morley experiment" (225). I will consider Michelson and Morley later in chapter 6 (pp 42-55).

(linear time) and that time flows uniformly in one direction so that 'the future' becomes 'the present'and then 'the past'..."(159). In *Ulysses*, Stephen quotes this theory *verbatim* at *U* 9.383-4.

Newton incorrectly theorised that "All motions may be accelerated or retarded, but the flowing of absolute time is not liable to change. The duration or perseverance of the existence of things remains the same, whether the motions are swift or slow, or none at all" (cited by Wilson 158). Similarly, Newton believed in absolute space, which was theorised as a kind of vacuous, fundamental background to the universe, a place completely at rest, from which it should be possible to measure the absolute motion of a body. Newton wrote, "Absolute space, in its own nature, without relation to anything external, remains always similar and immovable" (Wilson 160-1). In developing the relativity theory, Einstein deconstructed Newton's absolute time and absolute space, destroying the foundations of classical physics - and in *Ulysses* we encounter Bloom musing about these same concepts.

The difficulty with Newton's assumptions began to be apparent when physicists such as Michelson and Morley tried to prove absolute space existed:

> Nineteenth century scientists suggested that a luminiferous ether pervaded the universe and was the medium that transported light. But if such an ether existed it would surely mean that absolute space existed. Michelson and Morley wanted to establish the existence of the ether by determining the passage of the earth through it (Shallis 34-5).

However, they failed to find evidence of Newton's absolute space and the ether theory had to be abandoned as the "experiment demonstrated that the ether did not exist" (35). Bloom cites the ether theory word for word at *U* 17.262-3.

Einstein saw that he was unable to use the ether theory to determine any place of absolute rest from which all other velocities could be observed. He decided to assume that the observers are themselves at rest and all other motion is relative to them: the

relative motion postulate[6] - which Bloom illustrates perfectly at *U* 17.2305-10. The postulate was a huge simplification, but it came with a problem: "... the acceptance of the relativity principle must necessarily lead to a revision of our ordinary concepts of space and time" (Møller 5). Newton's theory of absolute, universal, linear time had to be abandoned for Einstein's relativity theory, which was based around an absolute speed of light, *c*, as defined by James Clerk Maxwell's equations for electromagnetic propagation.

Einstein stressed "the fact that it is impermissible to speak of absolute time, simply because absolute time cannot be observed; that only clock readings ... are relevant to the determination of time" (cited by Brian 156). In *Ulysses* clock readings occur everywhere; they are one of Bloom's major preoccupations. Further, Einstein gave a mathematical definition of a clock in a form physicists could use when he wrote in 1905: "We establish *by definition* that the 'time' required by light to travel from A to B equals the 'time' it requires to travel from B to A" ("On the Electrodynamics of Moving Bodies" 40). March writes, "The speed of light becomes no more than a conversion factor between units of space and time" (126). Bloom comes very close to quoting Einstein's 1905 definition at *U* 13.987-89.

Einstein also showed that space (i.e. distance) and time are relative to the velocity of light. As velocities increase towards *c*, "the concept of length has lost its absolute meaning" (Møller 46) and " the rate of clocks and therefore also the unit of time should ... depend on the state of motion of the inertial system" (30). Yet, Einstein had even stranger things to show us about the ultimate nature of reality, notably the "equivalence of energy and mass" (77); $E = mc^2$.

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[6] The relative motion postulate (also known as the relativity principle) was introduced by Einstein in 1905 with three almost incomprehensible sentences, in which he argued that the laws of physics were valid regardless of states of absolute rest, or relative motion – contradicting Newtonian mechanics:

> The phenomena of electrodynamics as well as of mechanics possess no properties corresponding to the idea of absolute rest. They suggest rather that, as has already been shown to the first order of small qualities, the same laws of electrodynamics and optics will be valid for all frames of reference for which the equations of mechanics holds good. We will raise this conjecture (the purport of which will hereafter be called the "Principle of Relativity") to the status of postulate ("On the Electrodynamics of Moving Bodies" 37-8).

Obviously, there are fundamental differences between Einstein and Newton. In the relativity theory, the mathematically definable quality of energy, *E*, replaces Newton's faulty concept of force, *F*. Møller writes, "In relativistic mechanics the concept of force has no longer any absolute meaning as it has in Newtonian mechanics" (73). After observing the fall of an apple in his Woolsthorpe orchard, and realising that the same force which caused the apple to fall also caused the moon to move in its orbit, Newton formulated the force of gravity, which he named "the universal law of gravitation" (Gribbin *Companion* 289-93). However, Newton postulated that this force of gravity acted instantaneously and continuously whereas Einstein proved that nothing could travel faster than the absolute speed of light, so Newton's theories of gravitation were incorrect. As March says, "space-time itself is curved, we can explain everything we know about gravity without ever having to mention a force" (140-1). Likewise, in a direct dismissal of Newton's gravity, March adds, "People who live in round worlds but insist they are flat are bound to invent forces like gravity" (140). In *Ulysses*, Bloom appears to know this when he gives a comic version of Newton's force of gravitational attraction in *U* 17.2162-8. In addition, since "the principle of relativity requires that all signals are propagated with a velocity smaller than or equal to *c*, it is impossible to maintain the Newtonian idea of forces acting instantaneously over finite distances of space" (Møller 163). Bloom demonstrates that he knows this relativity principle at *U* 17.1137-45. Likewise, Newton assumed that the geometry of space and time was flat - Euclidean geometry. Yet, Einstein's maths showed that the geometry of space and time is curved - "non-Euclidean geometry" (226). In *Ulysses*, Bloom performs gravitational experiments and interrogates Newton's notions of gravity at *U* 5.39-52, 8.44-80, 15.3367-90.

Einstein's general theory of relativity (1916) is also alluded to in *Ulysses*. Existing in ten horrendous equations describing gravitational fields, the general theory entirely abolished Newton's force of gravity acting as an instantaneous force of attraction. Einstein's theory states, "On account of the equivalence of mass and energy, we must assume that any energy distribution, thus for instance an electromagnetic field, will create a gravitational field" (Møller 310). Einstein's maths shows how gravitational mass or energy curves space and time, creating the field - the "Riemann-Christoffel" curvature (*ibid*). This curving of space or "warping of time" is a dominant feature of "Circe's" dance of the hours (*U* 15.4005-154).

Einstein's insight into the curvature of space and time resulted from an epiphany concerning the principle of equivalence. He postulated that gravity and acceleration are equivalent and that "gravitational fields have only a relative existence" (*Morgan Manuscript*[7]). Einstein "was astonished by the sudden idea that a man falling freely - and accelerating - would not feel his own weight" and that masses in free fall would move in an orbit, "their paths determined by the curved structure of space" (Brian 72). These ideas go under the name of a *Gedankenexperiment*. In *Ulysses*, they are alluded to at *U* 3.10-28, 8.52, 15.1539-55, 15.3374-76, 17.83-93.

The hardest of Einstein's concepts to understand - also alluded to in *Ulysses* - is "The Gravitational Red Shift of Light and Clocks" (Will 42). Kitty Ferguson writes:

> Time dilation isn't easy to understand. It helps if you know that time dilation and red shift are two faces of the same coin ... acceleration and gravity can have almost identical effects on things. Both ... can stretch electromagnetic waves.... Since whatever we perceive about events at a distance comes to us by some sort of waves, red shifting of those waves means we perceive those events at a slowed down rate: in other words we have time dilation (60).

In other words the slowing frequency of red shifted light waves effected by gravity or acceleration amounts to the slowing of time itself. To put it another way, the warping or non-linear curving of time is evidenced by the longer frequencies of red shifted light waves. In 1911 Einstein suggested "that the effect be looked for during a total solar eclipse" (Will 68). Then, on 29 May 1919, Sir Arthur Stanley Eddington observed a solar eclipse and "when the photographs were compared with others ... Einstein's prediction was borne out" (March 147). Interestingly, we find Bloom alluding to Einstein and Eddington and thinking about an eclipse at *U* 8.523-611.

Einstein's general theory of relativity brought about a revolution in cosmology. Newton's notions of the clockwork universe - the cosmos acting as a gigantic piece of clockwork governed by the three laws of motion and the force of gravity - had to be abandoned. In *Ulysses* we see "Wandering Rocks" abandoning the old Newtonian clockwork concept, while in "Ithaca" the new cosmology is a dominant feature of

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[7] *"Grundgedanken und Methoden der Relativitätstheorie in ihrer Entwicklung dargestellt"* in *Morgan ms.*

Bloom's musings. Significantly, Bloomsday closes on a note of relativity: *U* 17.3203-10. The enlarged full stop signals not only the final state of rest for Bloom, but also the end of the old Newtonian notions of time and space, to be succeeded by a new period of Einsteinian relativity, first in "Penelope", then in *Finnegans Wake*. However, Bloom is never conscious of the significance of his musings; he is denied the sort of epiphany that prompted Einstein's theories.