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A Study of the Legal Implications of Time Dilation in Accordance with Einstein's Theory of Special Relativity

Dr ALEXANDER SIMMONDS*

ABSTRACT

Albert Einstein's theory of special relativity dictates that, as an object travels close to the speed of light, it experiences time at a slower rate than an inert observer. This is often illustrated with reference to the thought experiment, known as the 'twin paradox', where one twin on Earth ages at a faster rate relative to their twin who is travelling close to the speed of light. The phenomenon, known as 'time dilation', is also observable with respect to gravitational fields. Essentially, the closer a given subject is moving relative to the speed of light or, in the case of strong gravitational fields, the nearer the subject is to the source, the slower they will experience time relative to an inert observer. This article seeks to explore the theoretical impact of this phenomenon on a range of legal issues. For example, could astronauts on a voyage that incurs significant time dilation be bound by an Earthly statute which, by their frame of reference, has been enacted in the future? Would a contractual term guaranteeing the durability of a spacecraft part for a number of years be assessed on the basis of Earth years or years within the frame of reference of the component itself? Would custodial sentences—or detention of any kind—within the vicinity of a supermassive black hole be classified as 'inhuman or degrading treatment' under article 3 of the European Convention on Human Rights because of the potential impact that the time discrepancy would have? To answer these questions, this article examines two matters: first, the legal implications of time dilation across a range of legal areas; and second, whether or not a singular legal framework would provide a significant counterbalance to this phenomenon. Since the time dilation effect is very real, the implications for the operation of law are too. As will be shown, these implications are both practical and, in some cases, as with contract law, doctrinal too in nature. It will ultimately be concluded that time dilation has the potential in theory to disrupt many, if not all, aspects of how the law operates. This article concludes that a unified legal approach to this problem would be difficult and that the most appropriate solution would involve, inter alia, the enactment of instruments so as to enable courts to determine the correct *forum conveniens temporis*.

Keywords: space law, computation of time, special relativity, space exploration, speed of light

* Lecturer in Space Law and Employment Law, University of Dundee; Barrister of the Inner Temple. Asimmonds001@dundee.ac.uk.

I. INTRODUCTION

On 27 May, 2023, the author gave a talk at the International Space Development Conference ('ISDC') in Frisco, Texas, on the potential impact of the time delay factor on legal proceedings that might arise between crew members on deep space missions.[1] 'Time delay' in this context means the delay in relevant communications brought about by the physical distance between those on Earth and those in 'deep space'—defined for these purposes as any distance whereby the delay in communications owing to the limitations of the speed of light is likely to impact substantive and procedural matters of law. Two basic scenarios were envisaged: first, disputes arising between crew members themselves, the more complex of which may fall outside the remit or authority of the Mission Commander; and second, disputes arising between such personnel and parties based on Earth.

The former scenario could involve a legal dispute of any kind that may be expected to arise as a matter of course between human beings working together in a stressful and unusual setting. There have been numerous studies in this area that suggest that such occurrences would be likely.[2] Whilst routine disciplinary matters, should they arise, would be expected to be actioned by the Mission Commander, this may be undesirable, for reasons of natural justice and/or procedural fairness, where the Mission Commander themselves are a party to such a dispute or where they have been accused of misconduct. In cases of this kind, communication with Earth-based authorities could be necessary.

The second scenario, involving disputes between Earth-based entities and the personnel of any such mission, could arise across as many areas as could arise on Earth. For example, a crew member's spouse may wish to obtain a divorce or a complex probate dispute may unfold following the death of an Earth-based relative.[3] Moreover, a 'galactic paisley snail' dispute may arise between a crew member and the manufacturer of space foodstuffs should harm arise from consumption during the mission.[4] There is also a recent precedent for such a dispute, which arose when astronaut Anne McClain was accused of illegally accessing her former partner's bank account from the International Space Station in what was termed the first criminal investigation in space.[5]

During the author's talk, the setting of Mars was used for the sake of convenience and to reflect current trends in desired human exploration. Proceedings arising between Earth-based entities and those in deep space are likely to involve some form of questioning by or of the other party or parties, as the case may be. In the case of criminal matters, one such party could be the relevant prosecuting or law enforcement authority on Earth. Per the second

[1] Alex Simmonds, 'In Space, the Other Side Should Have the Right to Be Heard' (2023) 28 Coventry Law Journal 23.
[2] For reference to a scientific behavioural study involving a simulated space environment, see Julián Hermida, 'Crimes in Space: A Legal and Criminological Approach to Criminal Acts in Outer Space' (2006) 31 Annals of Air and Space Law 405, 409. See also George S Robinson and Jeanne J Hughes, 'Space Law: The Impact of Synthetic Environments, Malnutrition and Allergies on Civil and Criminal Behavior of Astronauts' (1978) 19 Jurimetrics Journal 59, 65; Hamilton DeSaussure, 'Astronauts and Seamen—A Legal Comparison' (1982) 10 Journal of Space Law 165, 179.
[3] For further examples, see Simmonds, 'In Space, the Other Side Should Have the Right to Be Heard' (n 1) 26.
[4] *Donoghue v Stevenson* [1932] AC 562 (HL).
[5] Robin McKie, 'Nasa Astronaut "Accessed Ex-Partner's Bank Account from Space Station"' *The Guardian* (London, 24 August 2019) <https://www.theguardian.com/us-news/2019/aug/24/nasa-astronaut-allegedly-accessed-ex-partners-bank-account-while-living-on-iss> accessed 26 February 2024.

postulate of Albert Einstein's theory of special relativity,[6] the speed of light is constant and nothing can travel faster than it. Light can, in some cases, take as long as 22 minutes to reach Mars from Earth.[7] Therefore, a question asked during cross-examination could take 22 minutes to reach Mars and the answer could take a further 22 minutes to reach Earth, fundamentally undermining its effectiveness. As Denning LJ stated, 'the very gist of cross-examination lies in the unbroken sequence of question and answer'.[8]

At the close of this talk and in the author's subsequent academic article, it was concluded that some form of dispute resolution, possibly based around an inquisitorial model, would have to be agreed upon before embarking on space sojourns that would be likely to incur such a delay. Cross-examination, as discussed, simply will not operate effectively in such circumstances. Vesting absolute authority in the Mission Commander where this could grossly offend against principles of natural justice or procedural fairness (or where they would simply lack jurisdiction) would not be desirable within an already stressful environment.[9]

The author's second study concluded that the same factor has the potential to impact a range of other legal areas, such as the promulgation of statutes.[10] Would astronauts on Mars, or indeed any distance away from Earth that incurs a significant time delay, for example, be bound by an enactment at the point in time when it came into force? Or would they only be bound when it becomes accessible to them, in this instance between five–20 minutes after its commencement date on Earth? Other specific legal areas where it was concluded that the time delay factor could have a significant impact were contractual formation and certain aspects of tort. It was concluded that, owing to the range of different approaches across jurisdictions on Earth, further comparative study would enable us to establish whether a particular model could be adopted via a multilateral agreement regarding such matters prior to these missions.[11]

The concept for this article arose in an e-mail exchange that took place following the 2023 ISDC in Frisco between the author and Dr Pascal Lee, chairman of the Mars Institute. Dr Lee suggested that it would be a particularly interesting venture to build on aspects of these previous articles and to consider the implications of 'time dilation' as opposed to 'time delay', which was the subject of the author's previous works, as previously discussed. As explained in more detail later, time dilation is the phenomenon whereby time is experienced at a slower rate within the frame of reference of a moving object as compared to an inert one. These effects are only significant at high speeds and within strong gravitational fields. The legal issues that might arise from time dilation are, for the time being, largely theoretical in the light of the current technological state of the art but, nevertheless, make for an interesting legal study.

There are clear legal implications that could arise from time dilation. By way of addressing these implications, this article will first examine the concept of time dilation in further detail before outlining a hypothetical fact pattern to set the scene in which these legal implications can be examined. Jurisdictional dimensions will then be noted before some of what would likely be the most significant legal implications are examined in turn. These legal

[6] A Einstein, 'On the Electrodynamics of Moving Bodies' in HA Lorentz and others, *The Principle of Relativity: A Collection of Original Memoirs on the Special and General Theory of Relativity* (W Perrett and GB Jeffery trs, Dover Publications 1923) 41.

[7] Nola Taylor Tillman and Daisy Dobrijevic, 'How Long Does It Take to Get to Mars?' (*Space.com*) <https://www.space.com/24701-how-long-does-it-take-to-get-to-mars.html> accessed 29 July 2023.

[8] *Jones v National Coal Board* [1957] 2 QB 55 (CA) 65.

[9] Simmonds, 'In Space, the Other Side Should Have the Right to Be Heard' (n 1) 34–37.

[10] Alex Simmonds, 'Is the Speed of Law Faster than the Speed of Light?' (2024) 48 Journal of Space Law (forthcoming).

[11] ibid.

implications relate to the following: time itself; age; the promulgation of statutes; retrospective legislation; employment law; contract law; criminal law and sentencing; limitation periods; and issues that may arise in the context of communications sent at the speed of light between parties. It will then be concluded that the legal implications of time dilation are far-reaching and potentially destructive, although they could be tempered by the legislative and judicial creativity that is already inherent within existing practices.

Whilst this article is concerned with the impact of extreme time dilation, it is of note that the Biden administration in the USA recently directed NASA to explore the prospect of establishing a lunar time zone in the light of the forthcoming Artemis missions.[12] Part of the reason for this is to take account of the time dilation factor associated with the Moon's weaker gravitational field.[13] The White House Memo stated that '[k]nowledge of time in distant operating regimes is fundamental to the scientific discovery, economic development, and international collaboration that form the basis of U.S. leadership in space'.[14] In the coming years it will also be fundamental to legal development.

This article will focus on these matters from the perspective of the legal system of England and Wales, though reference will be made to other jurisdictions as appropriate. It is conceded that a limitation of this study is that it centres on the theoretical experience of only a few legal systems.

This article proceeds on the basis that the legal jurisdiction of Earth extends to those in space, as is confirmed by article 8 of the Outer Space Treaty,[15] which states that '[a] State Party to the Treaty on whose registry an object launched into outer space is carried shall retain jurisdiction and control over such object, and over any personnel thereof, while in outer space or on a celestial body'. Within the literature this idea is relatively uncontroversial.[16]

II. WHAT IS TIME DILATION?

The first postulate of Einstein's theory of special relativity is that '[t]he laws of (non-gravitational) physics assume the same form in all inertial reference frames. All inertial observers are equivalent.'[17] The effect of this, which is born out both theoretically and in numerous experiments, is that 'the time interval between two events depends on the state of motion of the observer'.[18] The 'practical' impact, as such, is that moving objects experience time at a slower rate relative to inert ones. This is what is meant by the expression, 'time is relative': those who move faster experience time moving at a much slower rate within their frame of reference compared to an inert observer. This is referred to in the world of physics as 'time dilation'.

[12] Arati Prabhakar, 'Memorandum for Departments and Agencies Participating in the White House Cislunar Technology Strategy Interagency Working Group' (Executive Office of the President, Office of Science and Technology Policy, 2 April 2024) <https://www.whitehouse.gov/wp-content/uploads/2024/04/Celestial-Time-Standardization-Policy.pdf> accessed 10 May 2024.

[13] ibid 2.

[14] ibid.

[15] Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies (adopted 19 December 1966, opened for signature 27 January 1967, entered into force 10 October 1967) 610 UNTS 205 ('Outer Space Treaty').

[16] See for example Helen Shin, '"Oh, I Have Slipped the Surly Bonds of Earth": Multinational Space Stations and Choice of Law' (1990) 78 California Law Review 1376; Hermida (n 2); Michael Chatzipanagiotis, 'Criminal Issues in International Space Law' (2016) 18 European Journal of Law Reform 105.

[17] Valerio Faraoni, *Special Relativity* (Springer 2013) 13 (emphasis removed).

[18] ibid 19.

The phenomenon of moving objects experiencing time at a slower rate than stationary ones can be traced back to at least as far as the works of the physicist Hendrik Lorentz and his subsequent 'Lorentz factor'.[19] This explains that time, along with other properties, will change along with an object's motion. The implications of special relativity and the resulting time dilation have been expressed in various thought experiments, the most commonly cited being the 'twin paradox'. In this scenario, one of a pair of identical twins leaves Earth travelling close to the speed of light and, upon their return, has aged at a rate much slower than their Earthbound twin.[20]

Although the result of these experiments may seem like science fiction, it has been tested in laboratory conditions at least as far back as 1941, where it was found that 'muons', a type of cosmic ray, effectively 'die' at a slower rate when travelling at higher speeds.[21] This result was replicated by CERN, which confirmed the theory,[22] as did the more famous experiment involving the transportation of atomic clocks on aeroplanes and the comparison of these clocks to a synchronised clock on Earth.[23] In line with the Lorentz factor and Einstein's theory of special relativity, this experiment demonstrated in a clearly observable fashion that a moving object experiences time at a slower rate than an inert one.

Building upon Einstein's theory of special relativity and 'time dilation', his theory of general relativity[24] postulates that the same effect also occurs with gravitational fields. The first significant test of Einstein's predictions in this field came in 1959 when Robert Pound and Glen Rebka conducted successful experiments involving gravitational redshift to prove that time moves slower within certain gravitational fields;[25] they found that time ran slower in the basement of their laboratory than it did in the building's penthouse. This was simply because the penthouse was further away from the Earth's gravitational field than the basement. Robert Vessot and Martin Levine followed this with their 1976 study,[26] which involved placing an atomic clock in a NASA rocket that was sent to a height of 10,000 kilometres. The clock on board the rocket ran at a faster rate than those on the ground. It is worth noting that such effects are not merely the concern of the academic and scientific community. In fact, Global Positioning System ('GPS') satellites routinely experience this effect as they run at a faster rate than clocks on the ground, requiring regular adjustment to counterbalance this effect.[27]

It should be noted for the sake of completeness that the study conducted in this article is based on the accepted proposition that time actually exists. As Sam Baron has pointed out,

[19] HA Lorentz, 'Simplified Theory of Electrical and Optical Phenomena in Moving Systems' (1899) 1 Koninklijke Nederlandsche Akademie van Wetenschappen Proceedings 427 (the Lorentz Factor can be expressed as ∑ m = 1 ∞ (J m − 1 2 (m β) + J m + 1 2 (m β)) = 1 1 − β 2 via the Bunney Identity).

[20] Andrew Zimmerman Jones, 'Understanding Time Dilation Effects in Physics' (*ThoughtCo.*, 24 February 2019) <https://www.thoughtco.com/time-dilation-2699324> accessed 13 November 2023. See also Leo Sartori, *Understanding Relativity: A Simplified Approach to Einstein's Theories* (University of California Press 1996) ch 6.5.

[21] See Bruno Rossi and David B Hall, 'Variation of the Rate of Decay of Mesotrons with Momentum' (1941) 59 Physical Review 223.

[22] J Bailey and others, 'Measurements of Relativistic Time Dilatation for Positive and Negative Muons in a Circular Orbit' (1977) 268 Nature 301.

[23] See JC Hafele and Richard E Keating, 'Around-the-World Atomic Clocks: Observed Relativistic Time Gains' (1972) 177 Science 168.

[24] A Einstein, 'The Field Equations of Gravitation' (1915) in AJ Kox, Martin J Klein and Robert Schulmann (eds), *The Collected Papers of Albert Einstein. The Berlin Years: Writings, 1914–1917*, vol 6 (Princeton University Press 1996) 244.

[25] RV Pound and GA Rebka Jr, 'Gravitational Red-Shift in Nuclear Resonance' (1959) 3 Physical Review Letters 439.

[26] Robert FC Vessot, 'Clocks and Spaceborne Tests of Relativistic Gravitation' (1989) 9 Advances in Space Research 21.

[27] See Neil Ashby, 'Relativity in the Global Positioning System' (2003) 6(1) Living Reviews in Relativity <https://doi.org/10.12942/lrr-2003-1> accessed 13 November 2023.

some theorists suggest that spacetime (the idea that, in addition to the three dimensions we perceive in daily life, time also exists as the fourth dimension) does not exist in reality.[28] The legal implications of this position will not be considered in this article. Firstly, the question of whether spacetime exists does not fundamentally alter the practical and observable effects of time dilation. Secondly, in line with the second postulate of Einstein's theory of special relativity,[29] the speed of light for all intents and purposes remains a constant. The impact of this as regards, for instance, the promulgation of enactments and the transmission of significant communications by either radio or laser will be legally significant regardless of the existence (or not) of time at a quantum level. This being written, the author remains open to further academic discussion of the legal implications of the existence (or not) of spacetime.

In summary, time dilation is a very real phenomenon, both in theory and in practice, as is shown by the studies outlined in this section. The legal implications of time dilation, then, are worthy of academic consideration and will be addressed in the remainder of this article.

III. A Hypothetical Fact Pattern

Although later sections of this article will deal with the implications regarding gravitational fields, most will consider the point of view—or frame of reference—of a group of astronauts travelling away from Earth at a speed where significant time dilation could feasibly occur. This article is concerned with the theoretical implications of time dilation, bearing in mind that current levels of technology do not allow for travel at these speeds, and nor are any travellers likely to experience gravitational fields strong enough to cause legally significant time dilation at any point in the near future. It is important that the reader keep the example of our astronauts in mind whilst reading this article.

Section III.A will examine the legal position as to time generally within the law of England and Wales. Section III.B will examine the law as it applies to age generally, whilst Sections III.F to III.I will look at specific substantive and procedural legal problems. Most of these sections will make reference to our group of astronauts by means of illustration.

While the actual values for time dilation can be calculated manually via a mathematical equation,[30] it is perhaps easier to understand the effects of time dilation by turning to the words of Valerio Faraoni:

> An astronaut on a spacecraft moving at speed *v* with respect to his twin on earth will measure a different time interval between his departure and his return than the time interval measured by his twin. For the astronaut, time 'runs slower' by a factor *y* with respect to the time measured by his twin on earth, but the astronaut would not have any perception of this fact.[31]

To study the legal implications of time dilation, it will be assumed in respect of special relativity—time dilation caused by speed—that the speed at which our astronauts will be travelling away from Earth (technically called their 'velocity') will be 161,325.3 miles per second,

[28] See Sam Baron, 'Eliminating Spacetime' (2023) 88 Erkenntnis 1289.
[29] Einstein, 'On the Electrodynamics of Moving Bodies' (n 6).
[30] Expressed approximately as $\frac{t}{t=\sqrt{1-v2/c2}}$
[31] Faraoni (n 17) 21.

or around 87 per cent of the speed of light.[32] The associated time dilation at this speed will mean that one year to our astronauts (within their frame of reference) will be equivalent to two years on Earth (the frame of reference of the 'inert' observer) at this velocity. This figure has largely been chosen with simplicity in mind when considering the computation of time as it applies to our astronauts and their interactions with the various legal issues discussed. It is easier for both the reader and author to work with whole numbers—working on the assumption of two Earth years to one 'space' year by the frame of reference of our astronauts is simpler than, say, two-and-a-quarter Earth years.

Speed will not be relevant in Section III.G as this is concerned with the dilatory effect of gravitational fields. The equivalent physical law here will be general—rather than special—relativity.[33] The effects of this were previously set out regarding GPS satellites[34] and rocket experiments:[35] time runs slower for those close to an object with a high mass or gravitational 'pull'. The theoretical dimensions of this will be addressed later.

In a previous article, it was asserted that the time delay factor between Earth and Mars could complicate any communication between these planets. This is because the time delay—as opposed to time dilation—factor means that certain legal procedures, such as cross-examination, could be significantly undermined[36] as outlined in the introduction to this article. In a subsequent article,[37] it was asserted that similar disruption owing to the time delay factor could impact more substantive legal matters, such as the promulgation of statutes. For example, where a statute comes into force that makes X illegal at midnight, UK time, would the same statute be said to be in force at this time for all UK subjects, even those who are at a distance of 20 light minutes away, when the UK clock strikes midnight? Could they avail themselves of an 'ignorance' defence?[38]

In such a scenario, the system of cross-examination would be undermined—perhaps even fatally—owing to the fact that the time between a question being asked and the answer being received would be significantly longer than in courtroom proceedings. The efficacy of the process would itself be called into question as any witness would have ample time to contemplate, if not the exact follow-up question, then at least the general direction of travel the questioning would be likely to take. Criminal convictions have been rendered unsafe in circumstances involving excessive judicial intervention which, it could be assumed, would not be as disruptive as the impact of time delay.[39] As Denning LJ reasoned:

> [T]he very gist of cross-examination lies in the unbroken sequence of question and answer... [E]xcessive judicial interruption inevitably weakens the effectiveness of cross-examination in relation to both the aspects which we have mentioned, for at one and the same time it gives a witness valuable time for thought before answering a difficult question.[40]

[32] Expressed as 299,792,458 metres per second, 186,000 miles per second, or 671,000,000 miles per hour.
[33] Einstein, 'The Field Equations of Gravitation' (n 24).
[34] Ashby (n 27).
[35] Vessot (n 26).
[36] Simmonds, 'In Space, the Other Side Should Have the Right to Be Heard' (n 1) 32–33.
[37] Simmonds, 'Is the Speed of Law Faster than the Speed of Light?' (n 10).
[38] ibid.
[39] *Jones* (n 8) 65.
[40] ibid.

John Henry Wigmore wrote that cross-examination is 'the greatest legal engine ever invented for the discovery of truth'.[41] Without interactions in real time, cross-examination would lose much of its effect as a 'legal engine'. Other systems would have to be devised in the light of the time delay factor.

This article will move beyond considerations of time delay and will explore the legal implications of time dilation with frequent reference to the scenario as outlined.

A. LEGAL CONSIDERATIONS AS TO TIME GENERALLY

When considering time dilation, it is important to uncover how time is defined in law. The time of commencement of an Act of Parliament can be found in section 4 of the Interpretation Act 1978, which states that:

> An Act or provision of an Act comes into force—
> (a) where provision is made for it to come into force on a particular day, at the beginning of that day;
> (b) where no provision is made for its coming into force, at the beginning of the day on which the Act receives the Royal Assent.

Furthermore, with respect to time, the Act states that 'whenever an expression of time occurs in an Act, the time referred to shall, unless it is otherwise specifically stated, be held to be Greenwich mean time'.[42] Elsewhere, a 'year' is regarded in law as an 'Earth year', so to speak.[43] This was first established in statute by section 1 of the Calendar (New Style) Act 1750 which, whilst initially brought in to reorder the calendar as it then stood, is still in force today:

> In and throughout all his Majesty's dominions and countries in Europe, Asia, Africa, and America, belonging or subject to the Crown of Great Britain, the said supputation, according to which the year of our Lord beginneth on the twenty-fifth day of March, shall not be made use of from and after the last day of December one thousand seven hundred and fifty-one; and that the first day of January next following the said last day of December shall be reckoned, taken, deemed, and accounted to be the first of the year of our Lord one thousand seven hundred and fifty-two.

This can also be seen in more modern instruments relating to the financial year, as set out in section 4 of the Income Tax Act 2007, which runs from 6 April to 5 April in any given year—a period of (usually) 365 days.[44] Furthermore, the 'time' provisions in the Civil Procedure Rules 1998 ('CPR') are set out in terms of 'days' and 'clear days'.[45]

Consequently, a 'year' when referred to in statute appears, indisputably, to mean a year in Earth terms. Likewise, the term 'day' at common law has been held to mean a period of 24 hours.[46] In astronomical terms, then, these units of Earthly measurements and their

[41] John Henry Wigmore, *Evidence in Trials at Common Law*, vol 5 (rev edn, Little, Brown & Co 1974) 32.
[42] Interpretation Act 1978, s 9.
[43] See for example the Law Reform (Year and a Day Rule) Act 1996, s 1 (abolishing the 'year and a day rule').
[44] Income Tax Act 2007, s 4(3).
[45] CPR 2.8(3). See also CPR 2.9(1)(a), which is expressed in terms of 'calendar date[s]'.
[46] See *Cornfoot v Royal Exchange Assurance Corporation* [1904] 1 KB 40 (CA).

corresponding legal definitions represent the movement of the celestial body known as the Earth as it rotates on its axis and orbits the sun. Therefore, the movement of planet Earth is, for legal purposes, the supreme reference point for matters relating to date and time. Since the law on planet Earth is patently concerned, at least in the vast majority of cases, with Earthly activities, this should not be unexpected. This is very important when considering the law's 'frame of reference' as regards considerations of relativity.

B. Legal considerations as to age

Whilst outlining the likely legal definition of time, it is also important to consider the legal parameters of age and aging. The effects of time dilation on age are a very common theme within science fiction[47] and lie at the heart of the 'twin paradox'. These effects will be revisited within this article. Exploring them at an early juncture, therefore, seems prudent.

Under section 9(1) of the Family Law Reform Act 1969, a person will age one year upon 'the commencement of the relevant anniversary of the date of his birth'. This phrasing is used in a number of other instruments, including the Social Security Contributions and Benefits Act 1992,[48] the Age of Majority Act (Northern Ireland) 1969,[49] along with other, often since-repealed enactments relating to military service, such as the National Service (Armed Forces) Act 1939.[50] The common law rule on age prior to the Family Law Reform Act 1969 was that a person attained a given number of years on the day *preceding* the anniversary of their birth,[51] but section 9 abolished this.

How would this affect our astronauts? On one construction of section 9, it could be argued that 'the relevant anniversary' is one year relative in space time from the perspective of our astronauts. However, there is also a very strong argument that matters of Earthly business—such as salary payments, pension accrual, and retirement dates—would be operating on the basis of Earth's frame of reference, i.e. the 'relevant anniversary' being assessed in terms of Earth years rather than years from the perspective of our astronauts. This point will be discussed further when the article considers contractual matters, but it is clear that the meaning of 'relevant anniversary' within this context would be a litigious point.

As mentioned earlier, this article assumes that time is running at a rate of two Earth years to one year for our astronauts. Therefore, if one of our astronauts were 47 years old when they left Earth, 20 years could have elapsed on Earth, but our astronaut would have only aged ten years on the basis of their frame of reference. Assuming the retirement age to be 67,[52] the effect of this would be that, legally, our astronaut would be entitled to retire even though only ten years would have elapsed from their perspective. Biologically, physically, *and* chronologically (in terms of our astronaut's own onboard clock and calendar), our astronaut would be 57, yet they would be entitled to draw a state pension on the basis of Earth's frame of reference, since, on the basis of Earth years in law they would be 67 years old.

Under current law, however, there is the notion that 'age' could be assessed objectively as opposed to on a purely chronological basis. This can be seen in sentencing in respect

[47] The 2014 Christopher Nolan movie, 'Interstellar', being a prominent example, which will also be referred to later in respect of criminal sentences.
[48] Social Security Contributions and Benefits Act 1992, s 173.
[49] Age of Majority Act (Northern Ireland) 1969, s 5(1).
[50] National Service (Armed Forces) Act 1939, s 21(3).
[51] See *Re Shurey* [1918] 1 Ch 263 (Ch) 266 (Sargant J).
[52] Unlikely by the time that near-light speed travel is a possibility but convenient for the sake of this illustration.

of perjury or otherwise false unsworn evidence given at inquests under schedule 6, paragraph 8 of the Coroners and Justice Act 2009, where 'a person's age is to be taken to be that which it appears to the court to be after considering any available evidence'. This is also a routine matter in asylum cases,[53] where assessing age may be difficult in the absence of relevant paperwork.[54] It may be wise to adopt a similar approach in respect of our astronauts who would be affected by time dilation. The 'available evidence' in such an instance could include evidence of our astronauts' voyage, including any telemetry data from the onboard clocks and computing systems, that would reflect time as actually experienced by the individual concerned as opposed to time experienced on Earth. Such an approach could also be adopted in respect of time in other areas too for the purpose of certain legal disputes. Assessing the passage of time on the basis of its rate of passage on Earth without considering that time may be experienced at a slower rate for those, such as our astronauts, who are travelling close to the speed of light would be to import an unhelpful Earth-centric determination of what is meant in law by 'time' generally.

When assessing the age of people—and, as will be covered later, the age of certain objects—the approach outlined above may present a more sensible legal solution. An Earth-centric approach to time would lead to some undesirable results.

C. TIME DILATION AND THE PROMULGATION OF STATUTES

Having considered the legal definitions of time and aging, we will now investigate the impact of relativity on the promulgation and commencement of statutes. An Earthly example of a case concerning considerations of time displacement in respect of promulgation is ***R v Logan***.[55] British soldiers in Hong Kong were convicted of offences under the Army Act 1955, which was enacted in the UK. The commencement date of the Act was 1 January, 1957. It was found that the soldiers had committed the offences on 1 January, 1957 at 2:30 AM, Hong Kong time. The argument at trial was that the Act was not in force at the time when the 'offences' were committed since, according with the commencement date, it was not yet 1 January in the UK and, therefore, the Act had no effect in Hong Kong. This argument was rejected, with the Lord Chief Justice stating:

> If an Act is said to come into force on January 1, it comes into force on the day which is January 1 in the particular place where the Act has to be applied... [T]he fact that it became January 1 in Hong Kong a few hours before the clock would actually show January 1 in England does not make any difference. As the Act comes into force on January 1, 1957, in Hong Kong, it comes into force on the day which is January 1 in Hong Kong.[56]

How might this authority assist in resolving legal problems arising from time dilation? For the following example, imagine that there is a digital clock on Earth and an identical one on the spaceship carrying our astronauts. The spaceship leaves Earth on 1 January, 2105 and

[53] See UK Visas and Immigration, 'Assessing Age for Asylum Applicants: Caseworker Guidance' (UK Visas and Immigration, 17 June 2011) <https://www.gov.uk/government/publications/assessing-age-instruction/assessing-age-accessible> accessed 9 December 2023.
[54] See ***R (B) v Merton LBC*** [2003] EWHC 1689 (Admin), [2003] 4 All ER 280.
[55] [1957] 2 QB 589 (CMAC).
[56] ibid 591 (Lord Goddard CJ).

quickly travels close to the speed of light so that one year for our astronauts is equivalent to two years on Earth. An Act comes into force on Earth on 1 January, 2108. From the frame of reference of our astronauts, it may be January, February, or March 2107 (allowing for the time it may have taken for them to accelerate safely to such a speed).

Taking the respective digital clocks on board the spaceship and back on Earth, the clock on Earth will show time passing at the rate experienced by those on Earth and the clock on the spacecraft will show time passing at the rate experienced by our astronauts. Owing to time dilation, the clock on the spacecraft will be running slower than the clock on Earth.

Remember again the Act of 1 January, 2108. This date will come to pass on Earth much quicker than it will for our astronauts. If time is running at the rate of two Earth years to one year for our astronauts, then, under special relativity, if our astronauts were to 'contravene' the 'Act' in 2107, they could be found guilty or liable (depending on what the Act concerns). Why? Because on the basis of the Earth-bound clock, 1 January, 2108 will have already passed on Earth and so the legislation will have come into force even though for our astronauts it is still, for argument's sake, July 2107.

The logic of ***R** v Logan* could provide a defence for our astronauts here. The soldiers in ***R** v Logan* were convicted as a result of being in a place where it was 1 January even though this date had not come to pass in the UK. For legislative purposes, they were 'in the future'—i.e. in a time where the Act *was* in effect. For our astronauts, their problem is not that they are in the future, but that they are in the past, and the past is, categorically, a time at which the relevant legislative enactment has not yet come into force. This case was effectively decided on the basis of the frame of reference of the soldiers rather than that of the statute. This line of reasoning may offer our astronauts a complete defence.

(i) Time as a 'Local' Concept

There is other authority to suggest that time would be regarded as a 'local' concept in such circumstances. *Curtis v March* was decided during a period when not everywhere in England observed Greenwich Mean Time.[57] One such place was Dorchester, where a trial took place at Greenwich Mean Time regardless of the fact that Dorchester did not observe this time zone. This led to the trial being overturned: since time was a 'local' concept, the trial should have taken place at Dorchester time. Taking the scenario of our astronauts who are experiencing time more slowly than people on Earth, would the logical conclusion from this be that legal matters relating to time—insofar as our astronauts would be affected—should be assumed to run on the basis of time as our astronauts are experiencing it?

Other cases have followed similar reasoning. In *Euronav NV v Repsol Trading SA*, in relation to a shipping dispute regarding the breach of a demurrage clause, it was determined that the breach should be assessed on the basis of the time zone where the breach arose and not the time zone where the contract itself was formulated.[58] In other words, the local frame of reference of the material facts in question was the relevant one.[59] In reaching this decision, Henshaw J quoted from *Carver on Charterparties*:[60]

[57] *Curtis v March* (1858) 3 H&N 866, 157 ER 719.
[58] *Euronav NV v Repsol Trading SA (The Maria)* [2021] EWHC 2565, [2022] 2 All ER (Comm) 65.
[59] Thanks to my student, Polina Myroschenko, for suggesting that this authority may be useful regarding time dilation in addition to the time delay context.
[60] Howard Bennett (ed), *Carver on Charterparties* (2nd edn, Sweet & Maxwell 2021) para 7-015.

> The charter may specify the particular time zone by which the relevant time is to be determined, e.g. GMT or UTC. If not, local mean time should be used...
>
> (v) The use of local time at the place of discharge gives rise to a single, clear and easily ascertainable date and time of completion of discharge. It tends to promote certainty and reduce the risk of confusion.
>
> (vi) It is inherent in a date based system that different time zones may apply to the events which define the start and end of the period, if they are in different countries...
>
> (viii) If it were appropriate to determine both dates using a single time zone, it would be more logical for that to be the time zone of the place of discharge. As already noted, the completion of discharge is a significant physical event, with a natural date, usually recorded in contemporaneous documents, and with several consequences under the contracts relating to the voyage.[61]

Instruction can also be taken from the making of payments in shipping contracts. For instance, the seventh edition of *Time Charters* states:

> It is suggested that, again in the absence of express agreement, the last moment for timely payment should be calculated by reference to the place where payment is to be made so that (for example) a payment to be made in New York and due on 30 April is timely if effected late in the afternoon that day in New York even if the ship is then in the Far East so that for her it is 1 May.[62]

Having considered these sources, it is apparent that treating time as a local concept for reasons of practicality has parallels with other legal areas. With this precedent in mind, it could strongly be argued that the frame of reference of our astronauts would be the correct one when determining whether statutes are in effect.

Other interesting situations arise when the problem of communicating new legislative enactments to our astronauts is considered. In the author's previous work, considerations were given to the argument that, owing to the time delay between Earth and Mars, it would be unjust to make someone on Mars liable for contravening an Earthly legislative enactment of which they knew nothing at the time of the alleged contravention. It was accepted that such circumstances might constitute 'justifiable' ignorance of the law.[63]

In circumstances involving time dilation, then, if a message carrying details of the new enactment is sent to our astronauts over the radio waves at the speed of light, the details of the new enactment may still bear its initial commencement date which, as previously outlined, may be in the future from within the frame of reference of our astronauts. An interesting legislative drafting exercise may need to be undertaken. One possible solution may be that legislation communicated via radio to our astronauts would have to be amended prior to communication so as to include an effective commencement date, i.e. one calculated to coincide with the date relative to our astronauts' frame of reference. Using the previous example

[61] *Euronav* (n 58) [35].
[62] Terence Coghlin and others, *Time Charters* (7th edn, Routledge 2014) para 16.22, as cited by Henshaw J: ibid.
[63] Simmonds, 'Is the Speed of Law Faster than the Speed of Light?' (n 10).

of an Act of Parliament that would come into force on January 1, 2108 on the basis of Earth's time, the same Act could have a specific section stating that the Act would not come into effect for our astronauts until this date arises on the basis of time as experienced by our astronauts. This is in contrast to the potentially troubling position of our astronauts being automatically bound by the Act as soon as it comes into effect on the basis of Earth time.

The timing of such a communication would have to be calculated precisely. The consequences of mis-timing such a communication would be undesirable: if the commencement date is too early, the crew may have committed criminal or other unlawful acts without knowing that they were prohibited. As will be discussed in the next section, this situation may draw parallels with arguments against retrospective legislation, where being prosecuted or being found liable under a law that was not in force at the time of the act or omission in question can, in many cases, seem offensive to commonly held notions of justice. Moreover, if the communication were to arrive too late, this might undermine the purpose of the legislation if its purpose is deterrence.

One possible solution to this would be the establishment of a new commencement device for legislation established in such circumstances. This would make plain that the enactment is to take effect as a fully promulgated law either on receipt by our astronauts or, if appropriate, within a set period of time thereafter as with other types of 'phased' legislation.[64]

(ii) Retrospective Legislation

One possible technique to preserve legislative legitimacy could be to frame any enactments retrospectively so that our astronauts would be bound irrespective of the commencement date. For example, the following section could be included in the Act:

> In respect of individuals and subjects experiencing time at a different rate owing to the chronological distortion arising from high-speed travel or proximity to celestial bodies exerting strong gravitational fields that result in the same, this Act will apply retrospectively.

However, such ex post facto lawmaking could prove to be a controversial move. Legislation with retrospective effect is defined in *Craies on Legislation* as that 'which takes away or impairs any vested right acquired under existing laws, or creates a new obligation, or imposes a new duty, or attaches a new disability in respect to transactions or considerations already past'.[65] Furthermore, Francis Bennion outlined the sentiment behind any opposition to such enactments: 'If we do something today, we feel that the law applying to it should be the law in force today, not tomorrow's backward adjustment of it.'[66]

Under English law, there is a general presumption against retrospectivity in legislation unless it can be shown that Parliament intended otherwise,[67] and the essential consideration arising in such circumstances is one of fairness to those falling afoul of any such provision.[68] This is not to say that all such provisions will be regarded as unfair per se, but that the greater

[64] For an example of this, see the (since largely repealed) Disability Discrimination Act 1995.
[65] Daniel Greenberg (ed), *Craies on Legislation* (12th edn, Sweet & Maxwell 2020) ch 10, fn 151.
[66] Francis Bennion, *Understanding Common Law Legislation: Drafting and Interpretation* (OUP 2001) 70.
[67] *Secretary of State for Social Security v Tunnicliffe* [1991] 2 All ER 712 (CA) 724 (Staughton LJ).
[68] ibid.

the potential for unfairness, the stronger the presumption against retrospectivity.[69] As Lord Reid stated, however, 'this presumption may be overcome not only by express words in the Act but also by circumstances sufficiently strong to displace it'.[70] One such example of an Act that did just this was the War Crimes Act 1991, which stated in section 1(1) that:

> [P]roceedings for murder, manslaughter or culpable homicide may be brought against a person in the United Kingdom irrespective of his nationality at the time of the alleged offence if that offence—
> (a) was committed during the period beginning with 1st September 1939 and ending with 5th June 1945 in a place which at the time was part of Germany or under German occupation; and
> (b) constituted a violation of the laws and customs of war.

As many would agree, there is a clear justification for the retrospectivity of this particular enactment.[71] Such legislation is only permissible when it is deemed to be in the national interest.[72] Whether it would be in the national interest to frame such legislation retrospectively as it applies to our astronauts would likely depend on the aims and objectives of the legislation in question. This course of action in its own right is prohibited in several other jurisdictions, such as the USA, where it is deemed unconstitutional.[73] It also finds disfavour with a raft of international instruments. For example, article 7(1) of the European Convention on Human Rights[74] ('ECHR') states that:

> No one shall be held guilty of any criminal offence on account of any act or omission which did not constitute a criminal offence under national or international law at the time when it was committed. Nor shall a heavier penalty be imposed than the one that was applicable at the time the criminal offence was committed.

This echoes article 11(2) of the Universal Declaration of Human Rights,[75] which states that '[n]o one shall be held guilty of any penal offence on account of any act or omission which did not constitute a penal offence, under national or international law, at the time when it was committed'. Furthermore, article 15(1) of the International Covenant on Civil and Political Rights[76] states that '[n]o one shall be held guilty of any criminal offence on account of any act or omission which did not constitute a criminal offence, under national or international law, at the time when it was committed'.

Therefore, should any Parliamentary enactments seek to impose criminal sanctions retrospectively, grounds for challenge could arise under the Human Rights Act 1998, which incorporates article 7 of the ECHR through schedule 1. Moreover, although this article is

[69] ibid.
[70] *Sunshine Porcelain Potteries Pty Ltd v Nash* [1961] AC 927 (PC) [938] (Lord Reid).
[71] Other examples of—possibly more controversial—retrospective legislation include the Caravans (Standard Community Charge and Rating) Act 1991 and the Statutory Instruments (Production and Sale) Act 1996.
[72] See *National & Provincial Building Society, Leeds Permanent Building Society and Yorkshire Building Society v UK* (1998) 25 EHRR 127.
[73] US Constitution, art 1, s 9, cl 3.3.
[74] Convention for the Protection of Human Rights and Fundamental Freedoms ('ECHR').
[75] Universal Declaration of Human Rights (adopted 10 December 1948) UNGA Res 217 A(III).
[76] International Covenant on Civil and Political Rights (adopted 19 December 1966, entered into force 23 March 1976) 999 UNTS 171.

concerned primarily with English law, similar challenges could arise within the respective home jurisdictions of any of our astronauts should they be nationals of another state.

As previously discussed, any statutes passed on Earth would, owing to time dilation, have been passed in the future from the frame of reference of our astronauts. If our astronauts were to be bound by an Act that came into effect on 1 January, 2108 and, owing to time dilation, their onboard clock read 1 January, 2107, the legislation would be de facto retrospective from their point of view, at least if the Act were *passed* after 1 January, 2107.

A further consideration arises in respect of the meaning of relevant judicial statements and article 7 of the ECHR. Taking the latter, there is no guilt in respect of an act or omission that was not criminal *at the time* when it was committed. In our scenario, our astronauts' clock would show time in the past relative to Earth, whereas the criminalising enactment itself would be in the future by *their* frame of reference. One analogy that could be drawn is that of a draft Bill on the day—or even an hour or less—before it receives royal assent. It exists, it is written down, and it has been passed by both Houses of Parliament. But it is not yet law. It is, in effect, enduring a brief period of legislative limbo and has no legal effect in spite of the fact that it clearly exists. If the Bill had, by some fluke, an incorrect commencement date stamped on it at that time—a day earlier than the commencement date—this still would not make it law until it receives royal assent. As soon as it does, it becomes legitimate, as a legally binding force. Availability of the law is a key factor of legitimacy.[77] How legitimate could any law be that has been given royal assent but has then been hidden completely from public view? It is strongly arguable that such a law would not bind its subjects until it was publicly available and that, when it was made so available, it would be contrary to justice and fairness to enforce it from the date on which it received royal assent.

This would, in effect, be the situation that our astronauts face. Regardless of whether the legislation itself is retrospective or not, our astronauts would not be aware of it. This therefore underscores the need for a specialised legislative promulgation measure as set out previously.

Consideration would need to be given to the effective commencement dates of statutes and the likely impact that these dates would have on our astronauts, with particular care given not to infringe human rights.

D. Employment Law

Moving away from legislative matters, it is interesting to note the potential impact of time dilation on specific types of legal dispute, such as contractual matters and questions relating to criminal law. The computation of time for the purpose of the law was found—unsurprisingly—to be taken on the basis of commonly agreed Earthly measurements, as found in Section III.A of this article. This raises interesting questions as regards contractual matters. Recall the time dilation that arose in the hypothetical fact pattern, where one year within the frame of reference of our astronauts is the equivalent of two years on Earth. If our travellers were due to be paid their salary in monthly instalments, there could be 20 years' worth of wage payments to return home to, even though, within their frame of reference, our astronauts had only worked for ten years.

Let us assume that, in our example, our astronauts are employed by an Earth-based entity who is responsible for paying their salary. Although it is well established that a court will

[77] Simmonds, 'Is the Speed of Law Faster than the Speed of Light?' (n 10).

not inquire into the value of consideration in contractual matters,[78] this would not necessarily stop a resentful employer from weaving a provision into their contract with the astronauts that states that payment is to be made on a schedule relative to, and consummate with, the position of our astronauts in space time. This would have direct financial consequences should our astronauts have, say, a mortgage on Earth or other financial commitments: 20 Earth years would have passed whereas our astronauts would have only been paid for ten of these, which would likely result in mortgage defaults. If such clauses were to become standard practice, it is unlikely that many employees would be willing to work on such terms.

It is worth noting that, for the purpose of establishing minimum levels of payment under employment contracts, section 2(3)(a) of the National Minimum Wage Act 1998 gives a power to the Secretary of State to make regulations regarding 'circumstances in which, times at which, or the time for which, a person is to be treated as, or as not, working, and the extent to which a person is to be so treated'. In our scenario, the question for the Secretary of State would be something akin to the following: Do our astronauts and those alongside them work on the basis of Earth hours or hours relative to their individual frame of reference which could, in fact, be half of the time that they are working from the point of view of Earth's frame of reference?

The Working Time Regulations 1998[79] prescribe that '"working time", in relation to a worker, means... any period during which he is working, at his employer's disposal and carrying out his activity or duties'.[80] Echoing previous findings, the units of time within the law are predictably and naturally stated in terms relative to time on Earth: '"day" means a period of 24 hours beginning at midnight'.[81] Maximum weekly working time is also set at 48 hours unless a worker opts out of this.[82] Moreover, a worker is entitled to a rest period of no less than 11 consecutive hours in each 24-hour period spent working[83] and, moreover, an uninterrupted rest period of no less than 24 hours within each seven-day period.[84]

The time dilation factor within our hypothetical fact pattern produces some interesting results against this backdrop. One hour within the frame of reference of our astronauts is two hours on Earth. Once our astronauts have worked a 24-hour week, in relative terms this would be the equivalent of a 48-hour week on Earth. Furthermore, their statutory rest period of 11 hours would be equivalent to 22 hours on Earth. If the hours and days in the Working Time Regulations 1998 are calculated on the basis of Earth time, with no accounting for relativity, in theory our astronauts would be entitled to half the amount of rest as their Earthly brethren. If our astronauts are experiencing time at a rate that is half that of Earth time, should their rest periods be assessed on the basis of Earth time, their rest time would be halved from their perspective.

For matters of such importance, it is likely that a purposive approach would be taken by the courts should a dispute arise under a statutory instrument like the Working Time Regulations 1998. As Lord Griffiths stated in the seminal House of Lords case of *Pepper v Hart*,[85] a 'purposive approach' is one that 'seeks to give effect to the true purpose of

[78] See the oft-cited example of *Chappell & Co Ltd v Nestle Co Ltd* [1960] AC 87 (HL) 114 (Lord Somervell).
[79] SI 1998/1833.
[80] ibid reg 2(1).
[81] ibid.
[82] ibid reg 4(1).
[83] ibid reg 10(1)
[84] ibid reg 11(1).
[85] [1993] AC 593 (HL).

legislation'.[86] The 'true purpose' of the legislation, in line with the EU Directive,[87] was to ensure that workers are given sufficient rest time outside of their working hours. It is likely that any such dispute arising under these Regulations would look to the time actually experienced by our astronauts for the purpose of rest as opposed to the Earth-based time. The latter approach would have the effect of depriving them of the right to adequate rest that Parliament sought to confer upon them. Alternatively, our astronauts could, like other professions, be excluded from the ambit of the Working Time Regulations 1998.[88]

Another alternative to this would be to include a provision in a contract between our astronauts and their Earth-based employers that could resemble the following:

> All references to time and date within this agreement as regards the payment of wages, rest-breaks, and related matters, are to be assumed to be on the basis of the time and date within the frame of reference of the employee, as displayed on the onboard computer, provided that the time and date displayed accurately reflect the impact of any temporal dilation experienced owing to the speed of travel and/or proximity to significant gravitational fields.

Should one of our astronaut's statutory rights be abrogated as a result of the time dilation factor, a purposive approach may be taken in order to give effect to the legislation. Moreover, litigation could be avoided with the addition of clauses establishing such rights by making plain that the agreement is to operate flexibly and with due regard to time dilation.

E. CONTRACTUAL WARRANTIES

Another interesting consideration arises in contract law. Taking the example of a component of a spacecraft, how would a manufacturer's warranty as to the quality or reliability of the component fare in circumstances that are affected by special relativity? Let us assume that there is a four-year manufacturer's warranty as to the quality or reliability of any given part of the spacecraft. For the sake of clarity, this term could be a condition or a warranty (or even an innominate term)[89]—the classification is not important.[90] The question is whether the stipulated time period means four Earth years or four years relative to the component's frame of reference in spacetime.

Complications arise from the first interpretation. If one year within the component's frame of reference is the equivalent of two Earth years, as previously calculated, and the component malfunctions after 2.5 years relative to its frame of reference, would it still be covered by the term? The term would have guaranteed the part for four years; however, five years on Earth would have lapsed within this period. Importantly, for our purposes, 2.5 years would have lapsed by the frame of reference of the subject matter of the contract. Therefore, would this term have ceased to apply?

[86] ibid 617.
[87] Directive (EU) 2003/88/EC of the European Parliament and of the Council of 4 November 2003 concerning certain aspects of the organisation of working time [2003] OJ L299/9.
[88] See Working Time Regulations 1998, reg 21.
[89] See *Hongkong Fir Shipping Co Ltd v Kawasaki Kisen Kaisha Ltd* [1962] 2 QB 26 (CA), in particular the dicta of Diplock LJ at 69–72.
[90] This article is concerned with how time dilation could impact any contractual term that is expressed with reference to a period of time rather than the specific consequences of breaching such a term and the available remedies.

If 'time' is exclusively calculated on the basis of Earth time, as discussed in Section III.A of this article, any contractual term would expire on the basis of Earth time and not on the basis of time as experienced from the perspective of our astronauts. To help us answer our question, it is instructive to observe how commercial agreements are interpreted by the courts. As Lord Hoffman pronounced, when attempting to ascertain the intentions of the parties to a contract, the court will consider 'what a reasonable person having all the background knowledge which would have been available to the parties would have understood them to be using the language in the contract to mean'.[91] Therefore, building upon Lord Hoffmann's statement, it would appear that, in our example, one party is saying to another, 'I promise that this part will work for X number of years. If it does not, you are entitled to damages (or to treat the contract as repudiated if the term is to be regarded as a condition).'

In our example of a spacecraft component, the person giving any warranty or making a representation capable of attracting binding contractual force is effectively saying: 'I promise that this component and certain of its mechanisms will work for at least 4 years.' For the purposes of mechanical wear and tear, or other engineering considerations, a warranty or representation is presumably given on the basis that the component in question is both fit for purpose and durable enough to withstand reasonable usage over a given period of time. The time period specified, then, should be the period of time within the component's frame of reference. If it were not, then the warranty or representation made would be good for only half the stated time: in our example, Earth time runs at half the speed that time does within the actual component's frame of reference. Surely such a representation as to durability is made on the basis of time experienced by the component in question? Per Lord Hoffman's statement,[92] the effects of time dilation could be said to be within what a reasonable person would assume to have been the background knowledge of both parties—particularly where a contract relates to a spacecraft component.

One might also draw upon the officious bystander test as it was expressed in *Shirlaw v Southern Foundries (1926) Ltd* by MacKinnon LJ on terms implied 'in fact':

> For my part, I think that there is a test that may be at least as useful as such generalities. If I may quote from an essay which I wrote some years ago, I then said: 'Prima facie that which in any contract is left to be implied and need not be expressed is something so obvious that it goes without saying; so that, if, while the parties were making their bargain, an officious bystander were to suggest some express provision for it in their agreement, they would testily suppress him with a common "Oh, of course!"'[93]

It is arguable that, if the officious bystander asked both parties in our case whether the four-year period meant four years of the component's existence relative to its frame of reference, rather than two years of its existence relative to its frame of reference, the answer would be 'of course'. The representation given by the offeror is that the component has been engineered to a standard whereby it can withstand the stress of its intended use for a period of

[91] *Chartbrook Ltd v Persimmon Homes Ltd* [2009] UKHL 38, [2009] 1 AC 1101 [14].
[92] ibid.
[93] *Shirlaw v Southern Foundries (1926) Ltd* [1939] 2 KB 206 (CA) 227.

four years. If the offeror intended it only to cover a period of two years in actual fact, they should have stated this.[94]

If the term is not implied, the purpose of the warranty would be defeated—it would effectively become meaningless in the face of its intended purpose between the parties. In *JN Hipwell & Son v Szurek*[95] it was held that a 'plain and obvious gap... inconsistent with the objective intentions of the parties'[96] necessitated the implication of a term to ensure that the agreement in question did not lack 'commercial or practical coherence' and it was thus implied 'as a matter of business necessity'.[97] Such an approach would also give 'business efficacy' to the contract, i.e. the implication is so obvious that it is needed to make the arrangement work.[98] As Sir Thomas Bingham MR stated in *Philips Electronique Grand Public SA v British Sky Broadcasting Ltd*, the implication of a term by the courts in such circumstances is an 'extraordinary power' and not one to be used wantonly.[99]

Such an implication as to time periods would be necessary in contracts between our astronauts and parties on Earth. As the Court of Appeal recently held, '[t]he business efficacy test will only be satisfied if, without the term, the contract would lack commercial or practical coherence. Its application involves a value judgment'.[100] Without the implication of such a term regarding the correct frame of reference, any such agreement may lack commercial or practical coherence: four years in this type of commercial context surely means four 'actual' years rather than years running at, in essence, twice their normal speed. Therefore, in line with such reasoning, it could be said that it is 'necessary' to imply such a term and that the court would be justified in exercising this 'extraordinary' power.

Deciding matters in this way, however, could bring disharmony as regards other contractual matters, such as those concerning employment contracts. To recap, if wages were to be paid according to our astronauts' frame of reference in this scenario, substantially they would only receive half of what could be expected if the wages were paid on the basis of Earth time. From the genesis of such contractual arrangements, it could be said that both parties would be acting at cross-purposes and that no *consensus ad idem* would be possible if the contractual subject matter were to be so grossly distorted or certain terms rendered unworkable. Rather than leaving such matters to be decided on the basis of the common law, statutory intervention would be the most sensible course of action to counterbalance these issues.[101]

F. CRIME

If a crime is committed by one of our astronauts during their voyage, some interesting questions arise. On what date did the crime occur? Was it the date within our astronauts' frame of reference or that of Earth?

The most relevant authority we have for such matters is *R v Logan*. This is authority for the proposition that, relating to statutory law at least, the time from which the statute is

[94] The question may then arise as to whether the two-year period meant two years by Earth's frame of reference or that of the component in question. The simplest resolution to this conundrum would surely be to assume that the parties meant the frame of reference of the component, otherwise counter-arguments could run and run 'Hall of Mirrors' style, ad infinitum.

[95] [2018] EWCA Civ 674, [2018] L & TR 15.

[96] ibid [32]–[33] (Hildyard J).

[97] ibid [38].

[98] See *The Moorcock* (1889) 14 PD 64 (CA) 68 (Bowen LJ).

[99] *Philips Electronique Grand Public SA v British Sky Broadcasting Ltd* [1995] EMLR 472 (CA) 481.

[100] *Yoo Design Services Ltd v Iliv Realty Pte Ltd* [2021] EWCA Civ 560 [51] (Carr LJ).

[101] Perhaps the Contracts (Time Dilation) Act 2107?

said to take effect is the time on the statute itself, rather than the time when an offence was committed.[102] Other potentially useful precedent was *Curtis v March*. The date on which the crime was said to take place in *R v Logan* was that relative to those convicted of it; in other words, the time when the offences were deemed to have been committed was the time when the offence took place and not the time as it actually stood in the place where the enactment came into effect. *Curtis* suggested that time may be a 'local' concept when determining disputes;[103] in other words, the effective time for the operation of the law should be the time as followed in the specific place in question. On this basis, it could be argued that the time and date of occurrence for any crime—or a civil transgression, for that matter—would be that within the local frame of reference. In the example of our astronauts, the time and date on which any such transgression was perpetrated would be the time and date as observed by our astronauts, as opposed to the time and date as observed on Earth.

Given the time dilation factor, one issue that could impact proceedings is that of 'unreasonable delay'.[104] Indeed, article 6(1) of the ECHR guarantees 'a fair and public hearing within a reasonable time'. It has even been recognised that such a delay need not have prejudiced the defendant's right to a fair hearing[105] and that delay alone can be a sufficient ground for a permanent stay of proceedings. Per the case law in this area, there is also a desire to avoid an accused waiting too long in suspense regarding their fate in these matters.[106] Indeed, John Jackson and Jenny Johnstone have written that this is the main justification for the rule.[107] They have further written that:

> As soon as a person is charged with a criminal offence, a number of constraints are imposed on the defendant which may be major (such as being held in custody and losing one's family and one's job) or more minor. In addition, the uncertainty as to the resolution of the charge can cause harmful psychological effects on both the defendant and victims and witnesses.[108]

In our scenario, the second part of this statement is of particular relevance. The mere factor of time delay owing to radio communication being limited to the speed of light will cause problems as regards the hearing of disputes in deep space.[109] One example is that cross-examination will be rendered extremely difficult or impossible, as previously discussed. This could make the hearing of substantive legal disputes troublesome in deep space.

The charging of our astronauts for a crime committed during the actual mission would be difficult owing to such factors and, indeed, such matters might indeed have to be resolved *in situ* as a matter of convenience. However, where a crime is alleged to have taken place before the astronaut left Earth—for example, where evidence is discovered by law enforcement after the alleged perpetrator has departed—the resulting investigations would be

[102] *R v Logan* (n 55).
[103] *Curtis* (n 57).
[104] *Bell v DPP* [1985] AC 937 (PC).
[105] *Porter v Magill* [2001] UKHL 67, [2002] 1 All ER 465, 509.
[106] *Attorney-General's Reference (No 2 of 2001)* [2003] UKHL 68, [2004] 2 AC 72 [94]: 'The jurisprudence of the European Court tells us that this part of the article seeks to ensure that the fate of those who are accused of crime is determined within a reasonable time. They should not be held too long in a state of uncertainty, with all the consequences for themselves and their families that this involves.' (Lord Hope).
[107] John Jackson and Jenny Johnstone, 'The Reasonable Time Requirement: An Independent and Meaningful Right?' [2005] Criminal Law Review 3, 9.
[108] ibid.
[109] Simmonds, 'In Space, the Other Side Should Have the Right to Be Heard' (n 1) 32.

conducted by Earth-based authorities who, in our example, would be experiencing time at a rate faster than our astronauts, including the suspect. Time dilation would present challenges here and the *in situ* resolution would not offer full redress owing to the fact that principal investigatory matters are being conducted on Earth.

The specific relevance of 'unreasonable delay' in the context of criminal investigations is that, notwithstanding the time that it might take for our accused astronaut to complete their voyage and return home, the time dilation factor could mean that many more years would have elapsed on Earth than for our accused astronaut. This passage of time could be particularly troublesome as regards expediency and fairness, even though our astronaut has themselves not experienced as significant a passage of time. One particularly important justification for trials being held within a reasonable time was put forward by Lord Steyn: '[I]t is recognised that lapse of time may result in the loss of exculpatory evidence or in a deterioration in the quality of evidence generally'.[110]

If our astronaut's accusers were on Earth, then the quality of evidence would indeed deteriorate with the passage of time, in some circumstances possibly rendering a criminal trial next to impossible.[111] If their accusers were with them on the spacecraft itself, this may not present as much of an issue since time, within their frame of reference, would have moved more slowly and the evidential value of eyewitness memory might not be as significantly decreased. Furthermore, and importantly:

> If vital evidence has as a matter of fact been lost to the defendant whether occasioned by the fault of the police or not, the issue is whether that disadvantage can be accommodated at his trial so as to ensure that his trial is fair.[112]

The burden of proving that injustice will arise is on the defendant who has to show, on the balance of probabilities, that 'owing to the delay he will suffer serious prejudice to the extent that no fair trial can be held: in other words, that the continuance of the prosecution amounts to a misuse of the process of the court'.[113] The longer the delay, the more likely it would be that evidence would be lost, which might result in an unfair trial. Moreover, as alluded to, the fallibility and limitations of human memory should always be considered in such circumstances.[114]

Underlying all of the above considerations is the central question of which clock would be the relevant one in any Earth-based investigations or in respect of incidents on board the spacecraft itself. The most fair and rational way of determining any outcomes in such matters would, in line with *R v Logan*, be to assess any case on the basis of 'local' time—any investigations on Earth would run in accordance with the local frame of reference, whereas onboard transgressions would be dealt with according to the astronaut's frame of reference. Another suggestion may simply be to apply the law as it stands on our astronaut's return or, more accurately, as it stood at the first moment when they could be said to have reasonable notice of it (such as when details of the law were received by them over radio waves).

This, of course, does not solve the problem of what would potentially be regarded as retrospective or ex post facto legislation, as has been previously outlined. Any such

[110] *Mills v HM Advocate* [2002] UKPC D2, [2004] 1 AC 441, 449.
[111] See Rebecca K Helm, 'Evaluating Witness Testimony: Juror Knowledge, False Memory, and the Utility of Evidence-Based Directions' (2021) 25 The International Journal of Evidence and Proof 264.
[112] *Clay v South Cambridgeshire Justices* [2014] EWHC 321 (Admin), [2015] RTR 1 [47] (Pitchford LJ).
[113] *Attorney General's Reference (No 1 of 1990)* [1992] QB 630 (CA) 644 (Lord Lane CJ).
[114] Helm (n 111) 266, 268.

prosecutions would still have to be conducted in a manner that is sensitive to the human rights implications of trying an individual on the basis of an offence that was not part of an enactment at the time of its commission, in addition to allowing for the degradation of evidence.

G. PUNISHMENT

Some very interesting considerations come into play when we consider custodial sentences. To appreciate fully the impact of these factors on sentencing, a slight shift in context is required away from the example of near-light speed travel, as was established in the hypothetical fact pattern earlier. Consider the scenario in the 2014 movie, 'Interstellar', wherein the protagonist spends time on a planet close to a black hole, the effect of which radically slows down the rate of time to the point where one hour on the planet's surface is equivalent to seven years on Earth. This is in line with Einstein's theory of general relativity.[115] Consequently, the protagonist in the movie has the highly distressing experience of witnessing his family age at a vastly increased rate which he observes through video messages received from Earth.

Suppose that the circumstances were such that the protagonist had been sentenced to a number of years—or even just one month—in prison on such a planet. Taking 730 as the number of hours in a given month and multiplying this by a factor of seven would result in the passage of 5110 years on Earth. As the prisoner's home planet would be radically different—or perhaps even non-existent—by the end of this one-month period, consideration has to be given to whether or not any custodial sentence in such circumstances would be regarded as unduly harsh in the vast majority of cases.

A detention of just one day—24 Earth hours—would result in the passage of 168 years on our prisoner's home planet. By this time, any immediate family members would likely be long dead. Moreover, such family members, particularly any dependents—or those who would likely become dependents within this time—would also be adversely affected to a significant degree. This aspect of detention was held to engage article 8 of the ECHR (the right to respect for private and family life). Hughes LJ stated the following in *R v Petherick*:

> [T]he sentencing of a defendant who has a family inevitably engages not only her own article 8 right to family life but also that of her family and that includes (but is not limited to) any dependent child or children. The same will apply in some cases to an adult for whom a male or female defendant is a carer and whether there is a marital or parental link or not. Almost by definition, imprisonment interferes with, and often severely, the family life not only of the defendant but of those with whom the defendant normally lives and often with others as well. Even without the potentially heart rending effects on children or other dependants, a family is likely to be deprived of its breadwinner, the family home not infrequently has to go, schools may have to be changed.[116]

Furthermore, Hughes LJ went on to articulate the correct test to apply in such matters:

[115] Einstein, 'The Field Equations of Gravitation' (n 24). See also Kip Thorne, *The Science of Interstellar* (WW Norton & Company 2014) 57.
[116] [2012] EWCA Crim 2214, [2013] 1 WLR 1102 [17] (Hughes LJ).

> [T]he right approach in all article 8 cases is to ask these questions: Is there an interference with family life? Is it in accordance with law and in pursuit of a legitimate aim within article 8.2? Is the interference proportionate given the balance between the various factors?[117]

In the light of this, custodial sentences would have to be exercised with a very high level of caution. It is indeed questionable whether any period of detention or custody in such circumstances would be considered proportionate save for in cases of the utmost severity.

Moreover, as regards the convict themselves, any such detention would be likely to result in a significant amount of psychological distress owing to, inter alia, the potential levels of inter-generational bereavement in extreme circumstances, in addition to the prisoner's knowledge that they would be returning to a planet that would be unrecognisable from the one they had left. Any length of detention, therefore, could be considered a form of torture or 'inhuman or degrading treatment or punishment' in line with article 3 of the ECHR.

H. LIMITATION PERIODS

Limitation periods within certain classes of litigation are also worthy of consideration. The European Court of Human Rights ('ECtHR') has stated:

> [L]imitation periods serve several important purposes, namely to ensure legal certainty and finality, protect potential defendants from stale claims which might be difficult to counter and prevent any injustice which might arise if courts were required to decide upon events which took place in the distant past on the basis of evidence which might have become unreliable and incomplete because of the passage of time.[118]

Limitation periods would be problematic because they are inherently time-sensitive provisions. Let us suppose that one of our astronauts took a product with them satisfying the definition in section 1 of the Consumer Protection Act 1987, i.e. any type of 'good'. The product causes damage to the spacecraft as a result of an electrical fire (owing to a defect per section 2). This would give rise to liability on the part of the producer of the product. The limitation period would be three years from the date of knowledge.[119] Crucially, no claim could be brought more than ten years after the defective product had been put into circulation.[120]

The same question arises—would this limitation period run at the rate of Earth years or years relative to the frame of reference of our astronauts? Let us suppose that the time dilation effect means that our astronauts are experiencing time at a rate of one year to three years on Earth.[121] If our astronauts waited any time between 3.5 to four years before sending a communication instigating legal action, the limitation period would have expired within the Earthly frame of reference. 3.5 years for our astronauts would be 10.5 years on the basis of

[117] ibid [18].
[118] *Oleksandr Volkov v Ukraine* (2013) 57 EHRR 1 [137].
[119] Limitation Act 1980, s 11A(4)(b).
[120] ibid s 11A(3).
[121] Notwithstanding the time delay effect of communicating with Earth-based legal representatives, which could be significant in and of its own right.

Earth time. This would be even more problematic with shorter time limits, such as the limitation period of three years for damage under the Consumer Protection Act 1987.[122]

In our example, then, if our astronauts were experiencing one year relative to three on Earth, the limitation period by Earth's frame of reference would have expired after one year of time as experienced by our astronauts. Other limitation periods include those for simple contracts, the limit of which is six years.[123] Rent arrears must also be recovered six years from the date that any rent became due.[124] Practical considerations dictate that arrangements in relation to property, where legal complications would be likely to arise from time to time, would have to be dealt with almost exclusively by an Earth-based agent.

The discretion vested in the courts for matters relating to limitation periods must be addressed here. Under section 33 of the Limitation Act 1980, courts retain a discretion to exclude time limits in respect of personal injury or death. Under section 33(3)(a), the court must have regard to 'all the circumstances of the case and in particular to... the length of, and the reasons for, the delay on the part of the plaintiff'.[125] The reasons for the delay would be the effects of general and special relativity, both in respect of the time dilation factor (owing to the speed at which our astronauts are travelling) and the time delay factor (based on the amount of time that instructions to commence any claim would take to reach Earth from our astronauts at the speed of light).

While it is likely that legal complications could arise under a tenancy agreement between one of our astronauts in the position of a landlord and an Earth-based tenant, or in respect of product liability or personal injury should it involve an Earth-based party, legal complications would also be likely to arise in matters of inheritance. Under section 1 of the Inheritance (Provision for Family and Dependants) Act 1975, an application can be made against the estate of a deceased individual by their spouse or civil partner[126] (current or, in some circumstances, former[127]), their child,[128] and a limited range of other individuals.[129] If one of our astronauts wished to make an application to contest a will or testamentary document under this Act, they would need to bring a claim within six months of the representation being made out.[130]

Of assistance would be the court's discretion to extend time limits under the 1976 Inheritance Practice Note.[131] If one year is the equivalent of two Earth years within our astronauts' frame of reference, notwithstanding the aforementioned time delay factor in communications, an application to the court—which must be requested expressly under paragraph 3—could be particularly late in arriving on the basis of an Earthly frame of reference. It is worth noting that extensions have been granted two months after the expiration of the six-month period[132] and sometimes up to five months after this period.[133] But what if such a delay in the case of our astronauts amounted to two or five years owing to time dilation? Would this be fair to the other beneficiaries involved? Surely such equitable considerations would form part

[122] Limitation Act 1980, s 11A(4).
[123] ibid s 5.
[124] ibid s 19.
[125] It should be noted that this does not apply to the ten-year time limit under the Consumer Protection Act 1987.
[126] Inheritance (Provision for Family and Dependants) Act 1975, s 1(1)(a).
[127] ibid s 1(1)(b).
[128] ibid s 1(1)(c).
[129] ibid ss 1(1)(d)–(e).
[130] ibid s 4.
[131] *Practice Note (Inheritance: Family Provision)* [1976] 1 WLR 418 [3].
[132] *Re Estate of Collier-White* [2022] EWHC 3029 (Ch), [2023] 1 P & CR DG20.
[133] *Kaur v Bolina* [2021] EWHC 2894 (Fam), [2022] 1 FLR 1192.

of the decision-making process. In cases of extreme time dilation, this would not necessarily be resolved in a way deemed favourable to our astronauts.

Time dilation, then, would have a particularly significant impact on the operation of limitation periods across a range of areas. One suggestion here would be for Parliament proactively to amend the Limitation Act 1980 so as to ensure that those experiencing time dilation are not precluded from enforcing their legal rights.

I. COMMMUNICATIONS SENT AT THE SPEED OF LIGHT

Some of the aforementioned effects could be offset by the fact that communications regarding the details of specific laws or those pertinent to imagined legal transactions would travel at the speed of light. Therefore, they would ultimately catch up with our travellers. However, communications sent will still take a long time to reach the intended recipients.

At a speed of 161,325.3 miles per second, our astronauts will travel approximately five trillion miles and the speed of light is around six trillion miles per year.[134] According to Einstein's theory of special relativity, the speed of light is a universal constant.[135] This means that, on the basis of current theory, nothing can move faster than the speed of light, including radio waves and lasers. Let us say that after one year relative to Earth time, a radio or laser communication is sent to our astronauts. In one year, this communication will have travelled six trillion miles, at which point our astronauts will have travelled 9.408 trillion miles. In another year, the communication will have travelled approximately 12 trillion miles and our astronauts will have travelled approximately 14 trillion miles. In yet another year, it will have travelled approximately 18 trillion miles and our astronauts will have travelled 19 trillion miles, and so on. For the sake of argument, we can say that any communications sent more than one year after our astronauts' departure will take roughly three years to catch up with our astronauts, even at the speed of light. Proceedings would still be subject to the effects of time dilation in respect of the two reference frames—that of Earth and that of our astronauts.

On this note, it is worth considering that 'real time' legal disputes between our astronauts and Earth would be very difficult to adjudicate.[136] Relatively straightforward aspects of law, procedure, and practice would be disrupted almost beyond practical utility by the combined factors of time delay and time dilation in our scenario. A situation could feasibly arise whereby the very law that one of our astronauts were being investigated for transgressing could be repealed by the time their answer arrived on Earth following the question being asked. It could even be repealed by the time the question reached them.

IV. TOWARDS A *FORUM CONVENIENS TEMPORIS*

The theoretical impact of time dilation upon legal proceedings is clearly significant. In a broad sense, any decisions regarding the appropriate temporal frame of reference would potentially stand to be resolved in a similar manner to how a court determines the *forum conveniens* in conflict of laws matters. In such matters, where the nature of a dispute potentially falls within two or more jurisdictions, the court may rely on various instruments to determine the

[134] And breaking Einstein's second postulate of special relativity in the process.
[135] Einstein, 'On the Electrodynamics of Moving Bodies' (n 6).
[136] Simmonds, 'In Space, the Other Side Should Have the Right to Be Heard' (n 1) 32–33.

appropriate jurisdiction—known as the *forum conveniens*.[137] Numerous factors are considered in making the appropriate determination, such as the defendant's connection to the jurisdictions in question or the place where, in the case of tort, the damage itself arose.[138] Given the range of permutations arising from the impact of time dilation, the most effective way to resolve such disputes would be for similar instruments to be enacted so as to enable similar hearings. Rather than determining the appropriate jurisdiction—the *forum conveniens*—the judicial question would be aimed at determining the *forum conveniens temporis*[139] (namely, which party's frame of reference should actually apply in the context of the dispute).

Where disputes arise between the astronauts themselves, this could be more difficult to resolve as regards which of Earth's laws actually apply and, importantly, when new laws made on Earth actually take effect within the astronauts' frames of reference. One possible solution would be to vest the commander of the mission with absolute authority, extending already existing rules, such as the ones that the USA enacted in the era of the Space Shuttle.[140] The crucial difference between the scenarios these rules were designed to cover and ours is that, in our scenario, there would be no means to appeal to a higher authority or 'simply' to return to Earth in the event of legal proceedings arising thereon. Instantaneous radio communications would not be possible in our scenario. In all probability, an analogous return to the rules that existed during days gone by of sea-faring, whereby crews would be under the exclusive jurisdiction of the ship's captain during their time at sea, may be likely.[141]

V. Conclusion

The legal implications of this study are that time dilation clearly presents a multitude of challenges for the law. Firstly, regarding legislative enactments, problems arise in respect of their commencement dates—by whose frame of reference would this be calculated? This has wide-ranging implications. As demonstrated in this article, time in a legal sense is presently calculated on a purely 'Earth-centric' basis, with all significant temporal references being made in terms of time as calculated on Earth. Legally, then, the commencement date and time for an enactment are based on the date and time of its promulgation on Earth. In turn, the implication is that an enactment passed on Earth would bind its subjects on the basis of the

[137] See for example Regulation (EU) 1215/2012 of the European Parliament and of the Council of 12 December 2012 on jurisdiction and the recognition and enforcement of judgments in civil and commercial matters [2012] OJ L251/1; Convention on jurisdiction and the enforcement of judgments in civil and commercial matters [1988] OJ L319/9.

[138] See Case 21/76 *Handelskwekerij GJ Bier BV v Mines de Potasse d'Alsace SA* [1976] ECR 1735.

[139] Or '*forum temporis*' or other such Latin designation as deemed appropriate.

[140] 14 CFR § 1214.700 (1981) (USA).

[141] See *Lamb v Burnett* (1831) 1 Cr & J 291, 148 ER 1430. See also DeSaussure (n 2). On the general matter of the rule of law in our scenario, it could be posited that the temporal and spatial dislocation would place our astronauts in the realm of a 'state of nature', as envisaged in the judgment of Justice Foster in Lon L Fuller's seminal work, 'The Case of the Speluncean Explorers' (1949) 62 Harvard Law Review 616, 620–26. This was a fictional account of five cave explorers who become trapped underground and resort to killing and cannibalising one of their party in order to survive. The article sets out five judgments which probe and consider the facts from differing legal perspectives. In Justice Foster's view, the defendants in question were, by virtue of their physical separation from the laws enacted within their jurisdiction—indeed, separated by an impenetrable 'curtain of rock'—removed from the legal jurisdiction entirely in the light of the surrounding circumstances. He advocated a 'purposive' approach to the facts of that case as may be the correct one in our scenario. Justice Foster concluded that the convictions of the men for murder should be set aside as to convict would not be within the purpose of the law in respect of being a deterrence. In our scenario, there are some instances where the object of certain legal instruments would be completely undermined, such as with the law relating to rest breaks under the Working Time Regulations 1998, in addition to the other considerations presented.

commencement date in question and be unconcerned with the frame of reference of those in a different temporal envelope (such as the astronauts in our hypothetical fact pattern).

The realm of conventional contractual transactions, which embody Earthly units of time as a matter of course, would be deeply impacted by time dilation. As noted in this article, if a contract refers to a period of four years, on the basis of the law as it stands, this would prima facie be calculated with reference to Earthly units of time. Additionally, similar implications arise in respect of contracts between individuals occupying two separate frames of reference. The implication for criminal sentencing is likewise drastic in situations involving close proximity to strong gravitational fields.

Regarding the overall implications of time dilation, then, it is clear that Parliament would have to intervene ex ante to counter some of the problems that could arise. Existing instruments would also require updates as to which frame of reference applies in given situations, although it is clear that not every possible issue may be contemplated. In such matters, a system of *forum conveniens temporis* would necessarily need to be invoked so as to ascertain the appropriate reference frame.[142]

One initial solution could be the promulgation of 'horologically sensitive reception statutes' which, in the style of those enacted by former colonies on gaining independence,[143] would implement the jurisdictionally relevant Earthly laws but provide that time periods within such laws are to be calculated with reference to relative time, as opposed to Earth time.

Ultimately, the implications of time dilation are wide and far-reaching, and consideration would need to be given by Parliament to amending and introducing new instruments to counter any possible injustice effectively.

[142] It is noted that other, broader implications may arise with respect to time dilation. Taking the previously outlined situation as regards a planet in close proximity to a black hole, it is interesting to consider what the broader implications would be for an entire city or civilisation on such a planet and how this would impact inter-planetary legal relations. The same implications would arise in respect of a starship with a city-sized population travelling at close to the speed of light. By what legal measure would time be calculated in these scenarios? If it is assumed that such entities still fall within the jurisdiction of a country on Earth—as a 'colony', for example—then, the issue of legitimacy within any such legislation could be dealt with by means of staggered commencement dates within the Earthly enactments as they are received by the entities experiencing time dilation. However, any such legislation would need to be specific as regards the definition of any time periods within. A 'day', for example, would most likely be defined in an interpretation schedule as 'a day relative to the receiving entities'. Assuming that such cities or civilisations have at least some power to make laws—at least of a limited nature (in the style of by-laws, for example)—any such enabling or parent Act conferring this power could also operate in a similar manner as regards the enactment of any such instruments under its auspices. A section to the effect of 'references to time and date within any bylaw made in accordance with section X of this Act, shall be presumed to mean the time and date relative to the lawmaker' could be included. This could be in addition to an amendment to the Interpretation Act 1978 requiring that references to time and date be made in a relative sense.

[143] See for example the Adoption of Laws Act 1843 (SA) (6 & 7 Vict No 2). All states of the USA famously introduced reception statutes following independence from Britain.