COSMIC JURISPRUDENCE: NAVIGATING THE LEGAL FRONTIERS OF SPACE AND TIME

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"Cosmic Jurisprudence: Navigating the Legal Frontiers of Space and Time" explores the emerging field of cosmic jurisprudence, a discipline that seeks to adapt legal frameworks to the unique challenges of space exploration and the scientific understanding of time. The article tackles pressing questions like how jurisdiction can be determined in the vast, borderless expanse of outer space, where Earth-based territorial laws no longer apply. It also considers the complexities of property rights on celestial bodies – such as whether a corporation could legally claim ownership of lunar resources or an asteroid's minerals – and the potential conflicts that might arise as nations and private entities race to exploit these extraterrestrial assets.

Beyond spatial concerns, the article ventures into the legal ramifications of time dilation, a phenomenon rooted in Einstein's theory of relativity, where time passes differently for objects moving at high speeds or in strong gravitational fields. This raises fascinating dilemmas: how might contracts be enforced if one party ages slower due to a journey near light speed? Could statutes of limitations still apply in a universe where time is relative? The author blends legal scholarship with insights from astrophysics and philosophy to propose innovative solutions, such as "time zone conventions" for space travel or adapting private international law to govern interstellar agreements.

The article's interdisciplinary approach makes it both practical and visionary. It not only addresses immediate legal needs – like regulating space tourism or mining operations – but also probes deeper philosophical questions about how humanity's perception of time and space might reshape justice and governance. As spacefaring technologies advance and permanent human settlements on Mars or the Moon become feasible, these issues grow increasingly urgent. The author's forward-thinking framework is both a practical guide for policymakers and a thought-provoking challenge to rethink legal traditions in light of cosmic realities.

This work stands out for its relevance to multiple fields: legal scholars will appreciate its rigorous analysis, scientists will value its grounding in physics, and futurists will find inspiration in its bold vision of a multi-planetary society. By connecting current legal principles to the boundless possibilities of the universe, "Cosmic Jurisprudence" offers a roadmap for humanity's next great leap while urging us to reconsider the very foundations of law in an ever-expanding cosmos.

Keywords: space law, jurisprudence, relativity, quantum physics, time, legal theory, space exploration, international law, philosophy of law, future law, private international law, private international space law, international law, public international law, Mars colonization, Moon resources, asteroids resources, space tourism, multiverse, metaphysics.

Problem statement

The rapid advancement of space exploration technologies has outpaced the development of corresponding legal frameworks, creating a significant gap in governance for activities beyond Earth's atmosphere. This issue is particularly pressing given the relativistic effects, such as time dilation, which complicate traditional legal notions like jurisdiction and contracts, impacting both scientific research and practical applications in space.

State of the problem research

Recent studies in space law have laid groundwork for regulating space activities. Yet, these efforts focus on spatial issues, leaving the temporal challenges posed by relativity underexplored. This article builds on these works to address those unresolved aspects.

Aim and objectives of the research

This article aims to propose a legal framework that integrates the relativistic nature of time into space governance. Its objectives are: 1) to assess current space law's limitations with relativistic effects; 2) to explore interdisciplinary perspectives on time and law; and 3) to develop guiding principles for a new framework. The goal is to achieve a practical model aligning law with space's physical realities.

Scientific novelty of the research

This study offers new insights by pioneering the integration of relativistic physics into legal theory for space, addressing how time dilation impacts legal constructs. Its interdisciplinary approach provides a novel framework, advancing space law and opening fresh research pathways.

Presentation of the main material

Additional novelty as an idea that generates further questions. Additional novelty is an idea that sparks further inquiries. This concept pertains to legal aspects, but it first requires an understanding of its technical prerequisites. This idea will be ahead of its time, much like the mathematical Fourier series of the 18th century, which found practical application and commercialization in the 21st century within smartphone display technology. The idea is grounded in well-established laws of astrophysics. When you observe any object in the Universe, you do not see it as it exists at the moment of observation. The speed of light, though the highest speed known to humanity today at which any signal can propagate through the Universe, is nonetheless finite. Regardless of how near or far an object is, you see it only as it was some time ago: at the moment it emitted or reflected light. *(In my view, this might partially offer a scientific explanation for phenomena like déjà vu or intuition – human "sensory" organs may, under certain conditions, "read" this information from objects earlier than usual, perhaps due to changes in blood composition, hormone release etc.)* The fact that light must travel from the observed object to the observer creates a knowledge gap about that object, which can only be bridged through mental deductions. Every observer in the Universe – unless they have spent significant time traveling at speeds close to that of light or have been in an extremely strong gravitational field (e.g., beyond a black hole's event horizon) – perceives "right now" as the same moment relative to the Big Bang: 13.8 billion years have elapsed since that event. For nearby objects, the speed of light is sufficiently high that the time difference between the source and the observer can often be disregarded. However, the farther we look, the further back in time we see, peering closer to the moment of the Big Bang.

This implies that when a distant observer looks at Earth, they see us as we were in the past. Here are the conclusions someone observing our planet might draw:

from Voyager 1, the farthest human-made spacecraft from us to date. Currently, Voyager 1 is 157.8 astronomical units (Earth-to-Sun distances) away – approximately 23.5 billion kilometers in more familiar terms. Launched in 1977, it reached its current position in 48 years, beyond the boundaries of our Solar System. It is one of five spacecraft presently moving away from our Solar System and will remain the most distant unless we launch a new craft to surpass it. Yet, despite being so far – beyond any planet, Moon, asteroid, or Kuiper Belt object in our Solar System – it sees Earth with a delay of less than a day. It perceives us as we were just 21 hours and 46 minutes ago. An observer on the Moon sees us as we were ~1.25 seconds ago; an observer on Jupiter, currently at its closest distance in 59 years, sees us as we were ~33 minutes ago; an observer on Pluto, 5.1 billion kilometers away, sees us as we were ~4 hours and 44 minutes ago. From any location within or near our Solar System, the depth of this glimpse into the past is minimal, especially on cosmic scales. Alternatively, consider this: even one light-year is an immense distance compared to our Solar

System's scale – a distance Voyager 1 won't cover for tens of thousands of years.

TOI-700, the first star system with an Earth-sized exoplanet discovered in its habitable zone, located 101.6 light-years from Earth. From this world, Earth appears as it was just after the end of 1920. A two-way message exchange would take over two centuries; no human would live long enough to receive a reply to their sent message [1].

Achieving technologies to travel at the speed of light is a matter of time – already explored, for instance, in the plots of Star Wars (a science fiction novel, specifically scientific; references to Star Wars during PhD defenses in the USA are standard) [2]. Thus, considering the above, a legal question emerges – a legal idea: what will serve as the reference point for the statute of limitations, for example, concerning a legal circumstance, transaction, or contractual relationship when traveling at the speed of light (as discussed further), moving to other planets, or across significant distances, given the time delay described? If they see us – or will see us – as we were in 1920, for instance, one could determine who, where, how, and when committed a tort or crime. This is a topic for dissertations by legal scholars in criminal, administrative law, or criminology. Will Earth's jurisdiction apply to such circumstances (since there is already evidence of radio signals from space [3]), or will it be the jurisdiction of human colonies on other cosmic objects closer to where legally significant events occur? Presently, conventions of Earth's space law could serve as a legal foundation, but this field holds potential for development, including in private international space law: property rights, the right to choose jurisdiction (lex loci), the location of property (lex rei sitae), which may influence the jurisdiction governing it (lex voluntatis). It is unknown whether humanity will encounter alien civilizations akin to Earth's, which might also have their own legal norms and concepts of justice. If so, what would be the source of private international law in such cases? Is it worthwhile to consider interplanetary, intergalactic, or similar private (conflict, conflictual) law?

Law and transactions in space, particularly in other galaxies. Legal matters and transactions in space, especially in other galaxies, remain highly theoretical today. Humanity currently lacks the technical capability to reach other galaxies, making references to such distant locales for applying private international law hypothetical, though theoretically plausible.

If we assume humanity develops technologies for intergalactic travel, the question of a transaction's reference point becomes intriguing. In private international law, the concept of the "place of transaction" (locus regit actum) determines which law applies to a given transaction, such as a contract or agreement, typically based on where it was executed.

When it comes to space travel and activities, legal issues grow more complex. Documents like the UN Outer Space Treaty of 1967 and its protocols outline principles for states' activities in space, but these primarily address the legal regime of planetary bodies in our Solar System, currently the focus of human exploration.

If bases or colonies are established on other planets or Moon, issues of law and the reference point for transactions may become pressing. The international legal community might need to develop new treaties and agreements to address determining the place of a transaction and the application of law in space. Yet, a broader question arises: who says law will exist in space, de facto and de jure?

Another fascinating point: what should be considered the reference point for time, a transaction, its jurisdiction, or the choice of applicable law (lex loci) in private international law during future travel at the speed of light? Moving at light speed, a person could, per the laws of physics, exist in two places simultaneously. *(There are written "religious" accounts suggesting Tibetan monks achieve a similar state during meditation, though this lacks scientific, official confirmation.)* During experiments at the Large Hadron Collider in Switzerland, a particle (and potentially, with technological advancement, a physical body) moving in a circle at near-light speed was recorded in two places at once in one experiment, raising potential questions about lex loci [4][5].

The speed of light in a vacuum is a precisely known constant: 299,792,458 meters per second. According to Einstein's special theory of relativity (now questioned for its finality, absoluteness, and infallibility, especially with advances in quantum physics), nothing can exceed light's speed. Under normal conditions, light appears instantaneous to us.

Until the 20th century, the world trusted Isaac Newton's views on objects and gravity. In the 1900s, Albert Einstein revolutionized our understanding. Einstein posited there is no single standard reference frame – everything, even time (especially as humans on Earth have chosen to define it), is relative. He realized the speed of light is constant, independent of the observer. If a person moves at 50% of light speed in the same direction as light, the beam appears the same to them as to someone stationary.

Traveling at, say, 90% of light speed yields intriguing observations. Primarily, a person at such speed experiences time dilation – time passes more slowly for them than for someone stationary. If 10 minutes pass for them, 20 minutes pass for the stationary observer.

Of course, despite the impracticality and obstacles of traveling at (or near) light speed, it would undoubtedly be quite an adventure [6].

Physicists have shown that in quantum reality, time operates differently – the past could be the future, or past, present, and future might coexist. For instance, Isaac Newton believed in a "universal clock" governing all life and death in the Universe. Per relativity, someone reaching light speed could halt "their" time's flow. Einstein went further, suggesting that traveling faster than light could reverse time [7]. If so, what then serves as a transaction's reference point? Travel into the quantum realm is vividly depicted, in my view, in Marvel's Ant-Man and the Wasp: Quantumania [8]. Personally, I believe that without mastering quantum speed technologies, exploring the Universe remains a dream.

This "game" with time (Χρόνος) is also officially evidenced by astronauts returning from space biologically younger [9]. Dare I suggest – almost the secret of immortality?

"At some point, you'll reach a point where you can see all objects that have ever passed through a black hole in the past. Looking back, you'll see what will ever happen in the future. And that's not even the most interesting part. Eventually, you'll be carried to a unique place where you can see the entire history of the Universe – past and future simultaneously. Unfortunately, there's no chance the human brain could process such information," says astrophysicist Charles Louis from NASA [10]. This offers scientific confirmation of the "game" with time, making the aforementioned questions relevant. Theoretically, a "vice versa lex loci" might apply.

This "game" with time, space, retrospection and regression appears in works like: the series Twin Peaks; sci-fi films Doctor Strange, Interstellar, Fringe, The Philadelphia Experiment; Metasensitive system (Max Morrison), the sci-fi novel The Habit of Dying (B. Pshenichnyi), Goy Gaya movement among others. The legal concept of "Act of God" in England and Wales law could extend to such phenomena. It occurs to me that humanity should already consider creating, shaping, and formalizing time zones for legal application in space, agreeing on their practical use, at least for currently reachable distances – perhaps starting with UN conventions like "conventions on time zones in outer space (lex praescriptionis actuum juridicorum)".

Hugh Everett and private international law in space. In the 1960s, renowned American scientist Hugh Everett (space.mit.edu/home/tegmark/everett/everett.html – MIT Kavli Institute) earned his PhD at Princeton University and later worked at the Pentagon. His work partially explored, if one might call it that, the "game" with time ("Ludus cum Tempore").

I venture to find intersections between the private international law aspects of regulating space activities and Hugh Everett's theory. Everett's multiverse theory (many-worlds interpretation) posits parallel realities, serving as a metaphor for the complexity of jurisdictional issues in commercial space law. My dissertation examines how private international law determines lex fori (law of the court), lex loci (law of the place of offense), lex rei sitae (law of the object's location), and lex voluntatis (law chosen by the parties) in space. Connections with Everett's research and legal regulation include:

I. Parallel Jurisdictions and Normative Conflicts

Everett's theory: parallel worlds illustrate the potential for coexisting legal systems in space (e.g., terrestrial laws vs. autonomous colony rules, such as on TOI-700d).

Legal basis: per the 1967 Outer Space Treaty (Art. VIII), the state registering a space object retains jurisdiction over it. Yet, for interplanetary missions, does lex loci delicti (law of the place of offense) apply if damage occurs on Mars, for example?

II. Space-Time Aspects of Transaction Regulation

Everett's theory: travel over vast distances or near light speed in the future may create time paradoxes (per special relativity).

Legal basis: The 1972 Convention on International Liability holds states liable for damages regardless of timing. But if a contract is signed during a private spaceflight, what is the lex temporis (time used to interpret the agreement)? This ties to the earlier idea of "time conventions" in space.

III. Party Autonomy in Space Contracts

Everett's theory: hypothetical parallel worlds reflect options for parties choosing applicable law (e.g., Earth law vs. colony law).

Legal basis: The 2015 Hague Principles on Choice of Law allow parties to select contract law. In space, this may conflict with the supremacy of the registering state's law (Outer Space Treaty, Art. II).

IV. Practical Implications for Lex Rei Sitae

Everett's theory: how is lex rei sitae determined for resources mined from moving asteroids?

Legal basis: The U.S. Commercial Space Launch Competitiveness Act of 2015 grants private firms' rights to space resources, but international law (e.g., 1979 Moon Treaty) prohibits national appropriation of celestial bodies, creating a conflict.

V. Lex Voluntatis (Law Chosen by Parties)

Everett's theory: in the multiverse, each "choice" spawns a new reality. Likewise, lex voluntatis lets contract parties "create" their legal reality via chosen law – e.g., a U.S. – EU company picking Singapore law for a lunar mission, akin to parallel worlds with distinct rules.

Legal basis: The 2015 Hague Principles (Art. 2) affirm party autonomy, but the Outer Space Treaty (Art. VI) mandates state responsibility for national activities, regardless of chosen law. Can lex voluntatis exempt a state from liability? The 2020 Artemis Accords (chapter 11) permit private resource use, contingent on international law compliance.

VI. Lex Personalis (Personal Law)

Everett's theory: personal laws (e.g., by citizenship) in space could create "parallel jurisdictions" for colonists – e.g., a French citizen on Mars under the French Civil Code, a U.S. citizen under Texas law.

Legal basis: The Outer Space Treaty (Art. VIII) grants jurisdiction to the registering state over a spacecraft's crew. For permanent colonies, this remains unresolved. The Moon Treaty (Art. XII) bans sovereign territories, so lex personalis may dominate regulation. In the EU, Rome III Regulation (Art. 5) governs personal law in private international law (lex fori), but its application to space is undefined – European law lacks provisions for space colonies, interplanetary marriages, or divorces in microgravity, creating a legal vacuum.

Key insights from Lex Voluntatis and Lex Personalis: 1) the complexity of multi-layered jurisdictions in space, where the law of the registering state, chosen law, and colonists' personal laws may coexist; 2) the need for new international tools, such as a space conflict-of-laws code (like Hague Conventions) or unified lex personalis rules (e.g., modeled on the ISS, where leading space powers' laws prevail).

Everett's theory metaphorically highlights this multi-layered nature, where each legal choice "creates" a new juridical universe. It doesn't contradict modern norms but exposes their inadequacy for space realities. Overcoming jurisdictional conflicts requires new agreements (e.g., Artemis Accords), accounting for temporal, spatial, and jurisdictional nuances; broader party autonomy in contracts with defined lex arbitri (arbitration law); and adapting private international law principles to space (e.g., maritime law analogies).

Integrating Everett's theory with legal aspects underscores the need for innovative approaches in commercial space law while respecting existing norms.

Prospects for private international space law. The relevance of developing private international law for space regulation grows with advances in space exploration, commercial missions, and celestial body development. As more states and private firms engage in space activities, the need for robust legal mechanisms and normative frameworks intensifies.

"I think the best form of government on Mars would be direct democracy. Everyone votes on every issue, and that's how it works," says Elon Musk. He views a Mars colony as vital for humanity's survival, noting, "I think it's unlikely we'll never have a world war again" [11].

In my view, future Mars colonies present a unique scenario demanding deep legal consideration, especially in private international space law. As a territory outside any state, it raises questions about legal status, residents' rights and duties, property, conflicts, and more: -property and land rights: how will ownership of Martian land be resolved? What mechanisms will regulate the sale, transfer, or inheritance of real estate and mineral rights on celestial bodies (Moon, Mars, asteroids – near or far)? -Relations with Earth: what about unclaimed inheritance in space? How will Martian colonies and Earth states interact? Which international documents will define the status and legal regime of future Martian territories? Will settlers from Earth to Mars eventually seek independence for their territory(ies)?

Elon Musk's SpaceX plans human Mars colonies within 5 – 6 years [12]. Soviet efforts to explore Venus (Venera 7, 8) recorded surface temperatures of 500°C. Given the complexity of space property issues, the international community may address them via treaties, conventions, and organizations like the UN Space Committee or The International Institute of Space Law.

Another emerging private venture involves sending urns with human or animal ashes into space [13]. Alongside Musk's "zero emission" concept for planetary pollution, I propose the term "biological debris free" for scientific advancement.

Future private firms may be hired to destroy asteroids, mitigating threats to Earth and other celestial bodies.

Further research questions emerge, such as space marriage registration amid space tourism, current legal regimes, and their consequences. If space law court rulings are issued by AI (judges overseeing), what is a lawyer's ultimate role (*S. Rekun*)? Private international law remains the "most incomprehensible" legal field (M. M. Boguslavsky).

Conclusions and prospects for further research

The study highlights an urgent need for a new legal framework that accounts for relativistic time effects in governing space activities. By analyzing the limitations of current space law – particularly its inability to address challenges such as time dilation and jurisdictional complexities – we have proposed principles that integrate jurisprudence with astrophysics. This approach represents a groundbreaking step in the evolution of space-related legal theory.

The interdisciplinary methodology opens new horizons for legal innovation. Future research should focus on testing these principles in hypothetical scenarios, such as long-term space missions or the establishment of extraterrestrial settlements, as well as on developing specific legal instruments, such as international treaties. This work underscores the critical importance of adapting legal systems to the realities of space exploration, thereby providing a robust foundation for humanity's presence in space.

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