Presentist Fragmentalism 1: Empirical Discovery, Falsifiable Prediction, Clocks

Modified parts of this note are in submitted papers. References are in progress.

1. Introduction

Since Heraclitus and Parmenides 2500 years ago there has been debate about whether time is an A-theory, which has both the A-series (future/present/past) and the B-series (earlier/simultaneous/later) or a B-theory, which has just the B-series. Additionally some have proposed that time is fundamentally just an A-series [refs.]. The A-series captures the dynamic flow of events from future through present to past. The B-series describes fixed relations of "earlier than" and "later than" between events. While physics has used B-series descriptions since Einstein's relativity theory,[1] this paper argues that both series are fundamentally necessary and irreducible to each other. This led to the Presentist Fragmentalist interpretation of quantum mechanics [refs.].

The paper makes several key contributions: First, it establishes an empirical basis for distinguishing A-series and B-series time through direct experience and observation. Second, it presents an important check on this result in giving five mini-arguments that A-theories should indeed be right. Third, it gives a novel kind of argument leading to falsifiable predictions. Fourth it gives a detailed account of clocks in this theory: sundials, analogue, digital, and atomic. Fifth it connects the clocks of a computer to the clocks of its software.

This note, then, effectively presents several arguments for the soundness of A-theories, and that their two series are required for a complete description of time in physics.

2. The Empirical Discovery of the A-series and B-series

2.1 Historical Context

With Einstein starting in 1905, it was noted that time itself is relative [11]. The way in which it is relative is that a (relatively) moving object or frame of reference has different events simultaneous to each other than a (relatively) non-moving object or frame of reference. In 1908, Minkowski made the epochal observation that there is an invariant which can be used to combine space and time into 'spacetime' as a function of 4 variables, (t, x^a) [29].This mathematical framework [31] has proven essential for understanding spacetime structure. In 1889, Bergson introduced the notion of tensed experienced time [3], later developed by contemporary philosophers [8, 10, 24]. Contemporary

1 Arguably using just the B-series of time in physics goes back at least to Galileo. In the *Principia* Newton did indeed distinguish between the two notions of time, but he only used the B-series to formulate his theories. We have already formalized the A-series to include a parameter τ in units of e (the fundamental unit of temporal experience), whereas the B-series parameter is t in units of seconds as usual [Refs.].

quantum mechanical interpretations [3, 9, 11] have brought new perspectives to these foundational questions about time and measurement [30].

2.2 Empirical Basis

The empirical distinction between A-series and B-series time can be presented in one’s experience. Consider a simple example: dinner tonight is 5 hours later than lunch today, and they remain that way (changes in relativistic frame of reference addressed below). Thus B-series values do not change. However, lunch, and later dinner, are first in my future, then in my present, and finally in my past. The A-series values change.

This distinction can be verified through differentiating between one's experience of time and one's *thoughts about* one’s experience of time. The former leads to the A-series and the latter leads to the B-series. This realization requires a certain amount of ‘internal technology’ just as solving Schrodinger’s equation for a given potential requires ‘mathematical technology’ and measuring the mass of the Higgs boson at CERN requires ‘physical technology’. This capability can be developed through various practices, including meditation, and solving (not merely reading about) Zen koans. Why is reading about them not enough? Because, for example, one can read all the books in the world about swimming but still not be able to swim. The relevant state for preforming the experiment of investigating time is called many different things, including ‘enlightenment’, ‘conscious’ (in the spiritual sense, not the philosophical sense), ‘awakened’, and ‘liberated’. This is not a matter of definitions or pretending but of finding the outcome of experiment that can be repeated and verified by anyone, given enough internal technology. But this is not anthropomorphic. As each temporal series is real, each quantum system necessarily has both series. In this way each quantum system forms a ‘fragment’ of reality based on each system having its own A-series which is not synchronized with the A-series of other systems. There have been other notions of fragmentation of reality in the literature, see Merriam [27, 28].

This was proposed by the Presentist Fragmentalist realist interpretation of quantum mechanics not because it works, but because of a deeper philosophical consideration. Here is a brief argument using the every-day example of a red firetruck. When you and I look at a red firetruck, it cannot be verified that your ‘red’ is qualitatively the same as my ‘red’. What you call ‘red’ might be what I would call ‘blue’. As there is no possible verification of the fact, there is no fact of the matter as to whether we see the same ‘red’, as it must be encoded into the ontology. This obviously applies to all qualia whatsoever. Meanwhile, the A-series and its ‘becoming’ are usually thought to be qualic [refs]. The consequence is that there is no fact of the matter about whether your A-series is the same or synchronized with my A-series, which is not a psychological artifact but indeed applies to each quantum system no matter how small or simple. These A-series, then, lead to a fragmentation of reality in this way.

3. Arguments for A-theories and Presentist Fragmentalism

One may ask if the above results are spurious. In fact there is strong theoretical support for A-theories. Here are five mini-arguments.

3.1 One argument that the two series cannot be reduced to each other is that the debate itself has gone on for 2,500 years, since Heraclitus and Parmenides. If one series were clearly more fundamental than the other this would not have happened.

3.2 Another argument is that several thought experiments implicate the same realist interpretation of quantum mechanics that employs both series (Presentist Fragmentalism).

3.3 A third argument is that this interpretation gives a single account of both manifest time and relativistic time.

3.4 A fourth argument is that this theory has been derived from more fundamental philosophical considerations (spectrum inversion), which we don't go into here.

3.5 Finally, τ and t can be varied independently. The independent variability of t and τ means that B-series duration and A-series temporal experience do not have to correspond directly.

4. Falsifiable prediction

We make an unusual argument which appears trivial at first but is quite strong and leads to a falsifiable prediction. It is an 'experimental' result that there are *two* temporal parameters required for narrowing the search for finding a video on YouTube. In its apparent triviality lies this argument's strength. These two temporal parameters are "UPLOAD DATE" for example, within a day of 'now' or within a week of 'now,' etc… which is the A-series, and "DURATION" namely, the end of a video is 4 minutes later than the beginning of the video, or 20 minutes later than the beginning of the video, etc... which is the B-series. If one series were really more fundamental than the other, having just one temporal parameter would surely have been sufficient. The search parameters cannot, we predict, be reduced to *one* search parameter that has the same functionality. We don't see the experimental result as an epistemological or UI curiosity but as a very important check on and confirmation of ontology. The very mundaneness of this observation is a strength and makes this a powerful critique of B-theories.

The dual nature of time manifests consistently across human organizational systems. Music composition requires both tempo, which represents the flow of musical time relative to "now," and duration, which captures fixed time intervals between notes. Similarly, digital media platforms universally employ two temporal frameworks: when content was released relative to the present, and the unchanging length of that content.

This pattern extends through professional domains. Project management tools must track both deadline dates that flow from future to past, and fixed task durations. Transportation schedules combine departure times that progress through "now" with journey lengths that remain constant. Medical systems record both diagnosis dates that become increasingly past and treatment periods with fixed spans. Educational institutions organize around both course start dates that advance through the academic calendar and credit hours that measure set instructional time.

Manufacturing processes demonstrate this duality through production dates that move through time and assembly durations that remain fixed. Perhaps most tellingly, daily scheduling requires four distinct temporal concepts: when appointments are created, their scheduled start times, their durations, and their relative urgency. Each of these elements serves an essential function that cannot be reduced to or derived from the others. Calendar systems must therefore maintain both modification histories that flow through "now" and fixed time allocations - reflecting the fundamental, irreducible distinction between time's passage and time's measure.

It is unlikely that all of these could have been modeled using just one parameter.

5. Clocks Operate in A-series and B-series Time

Any theory of time must give an account of clocks. We look at sundials, analogue clocks, digital clocks, and atomic clocks.

SUNDIALS: In our A-theory, a sundial's shadow represents where a B-series event (the sun's position) passes through the unique "now" of that sundial system. The fixed B-series relations are the geometric relationships between sun positions and shadow positions. The operation of the sundial demonstrates how B-series relations flow through the A-series "now," with each new shadow position becoming present, then past. The sundial system contains both the regular B-series progression of sun positions and the privileged "now" through which these positions pass, making it one of our earliest demonstrations of both temporal series in a single device.

ANALOGUE CLOCKS: An analogue clock's hands physically embody B-series relations through their fixed mechanical relationships - the hour hand must complete one rotation for twelve rotations of the minute hand, creating an unchanging series of earlier/later relations. However, the actual operation of the clock involves these B-series positions passing through the unique "now" of the clock system. When we read an analogue clock, we're observing where the B-series mechanical states pass through the A-series present moment. The smooth motion of the hands illustrates how B-series relations flow through the single "now" while maintaining their fixed relationships to each other.

At their core, analogue clocks rely on a quartz crystal oscillator, where precise voltages cause the crystal to vibrate at a specific resonant frequency (usually 32,768 Hz, chosen as 2^15 cycles per second). The crystal's piezoelectric properties create an electrical signal at this frequency. These oscillations represent B-series events - a fixed sequence of crystal states with unchanging earlier/later relations. The oscillations pass through the clock system's unique "now," with electronic circuits counting these transitions to drive the mechanical movement of the hands through gearing.

The quartz crystal's atomic lattice structure provides stability to these oscillations - the regular spacing of silicon and oxygen atoms determines the natural frequency. When voltage is applied, the crystal deforms in a predictable way based on these atomic arrangements. Environmental factors like temperature can affect the spacing of these atoms, which is why precision quartz clocks often include temperature compensation. The physical crystal structure maintains B-series relations through atomic-level regularity.

The conversion from crystal oscillations to mechanical motion requires precisely dividing down from 32,768 Hz to 1 Hz for the second hand. This represents translation between atomic-scale B-series events and macroscopic motion through the clock's "now." The gear train preserves fixed ratios between hands while their positions flow through the A-series present moment. Each crystal oscillation becomes present then past as B-series atomic states pass through the clock system's privileged "now."

DIGITAL CLOCKS: Digital clocks make the distinction between A-series and B-series particularly clear. The B-series is represented by the programmed sequence of numerical states, while the A-series is manifested in which number is currently displayed - that is, which B-series state is passing through the clock system's "now." Each numerical state has fixed earlier/later relations to all other states (B-series), but these states pass through a unique privileged present (A-series) for that clock system. The discrete nature of the display changes also aligns with the quantum mechanical aspect of the theory, where operators move B-series events through "now" in discrete steps.

Digital clocks also typically use quartz crystals as their time base, but rather than driving mechanical hands, the crystal oscillations trigger electronic counters that segment time into discrete digital states. The 32,768 Hz crystal frequency is divided by binary counters to generate precise 1 Hz timing. At the atomic level, the regular arrangement of silicon and oxygen atoms in the crystal lattice ensures stable oscillation frequency. These atomic states form B-series relations that pass through the clock's unique "now."

The binary counting system creates a discrete series of numerical states encoded in electronic flip-flops. Each state has fixed earlier/later relations to all others (B-series) while passing through the clock's privileged present moment (A-series). The LCD or LED display shows which numerical state is currently present. The discrete nature of both the crystal oscillations and digital states aligns with quantum mechanical operators moving B-series events through "now."

The precision of digital timekeeping ultimately derives from atomic-level regularity in the quartz crystal structure. Temperature changes affect atomic spacing and thus oscillation frequency, which is why precise digital clocks include temperature-compensated crystal oscillators (TCXO). The conversion from 32,768 Hz crystal transitions to displayed seconds represents translation between microscopic B-series events and human-readable time as states pass through the clock's "now."

ATOMIC CLOCKS: Atomic clocks represent the deepest physical manifestation of our A-theory. The B-series consists of the ordered sequence of cesium transitions, which maintain fixed earlier/later relationships. These transitions pass through the unique "now" of the atomic clock system, with each transition becoming present then past. The quantum nature of the transitions connects directly to our theory that quantum mechanical operators may be the fundamental operators moving B-series events through "now." Atomic clocks thus demonstrate both the classical B-series aspect (fixed transition relationships) and quantum A-series aspect (discrete transitions through a privileged present) of temporal becoming.

Atomic clocks achieve unprecedented precision by using the quantum transitions between hyperfine energy levels in cesium-133 atoms. The ground state of cesium-133 splits into two hyperfine levels due to interaction between electron and nuclear spins. The transition frequency between these levels is exactly 9,192,631,770 Hz - this defines our second. These quantum transitions represent B-series events with perfectly fixed earlier/later relations passing through the clock system's unique "now."

The clock operates by tuning a microwave cavity to this precise frequency to drive transitions between the hyperfine states. Cesium atoms are cooled and collimated into a beam that passes through the cavity. If the microwave frequency matches the hyperfine splitting, atoms are excited to the upper state. A quantum detector measures how many atoms make the transition. The detection represents the moment these B-series quantum events pass through the clock's privileged present moment. Feedback loops keep the microwave frequency locked to the atomic transition.

The quantum mechanical nature of the hyperfine transition is essential - atoms can only absorb energy at exactly the right frequency due to the discrete energy levels. This quantum behavior aligns perfectly with our theory that quantum operators may be the fundamental operators moving B-series events through "now." The cesium transition frequency remains constant due to the unchanging laws of quantum mechanics, providing stable B-series relations that pass through the atomic clock's A-series present. The precision achieved (about 1 second error per 100 million years) demonstrates the fundamental consistency of quantum events flowing through "now."

The theory presented in these papers suggests that our current physics, by focusing almost exclusively on B-series time, has missed something fundamental. While B-series physics has been tremendously successful (as evidenced by the precision of atomic clocks), the fact that every clock ultimately requires both A-series and B-series aspects suggests a deeper truth about time.

The quantum mechanical operator may be the operator that moves B-series events through ‘now’ (in Presentist Fragmentalism). This would explain why quantum mechanics seems to require irreducible operations rather than just states. It also suggests why unifying quantum mechanics with general relativity has been so difficult - we've been trying to do it purely in B-series terms when we need both series.

This aligns with the seemingly trivial but profound observation about YouTube's UI - the fact we can't build a working time-based interface with just B-series parameters reflects something fundamental about reality itself. Just as clocks need both series to function, physics may need both series to give a complete description of nature. This has led to new approaches to quantum gravity [refs.].

6. Hardware to software

Computer hardware clocks fundamentally rely on quartz crystal oscillators that operate at specific frequencies (commonly 32,768 Hz), where the crystal's atomic lattice structure provides stable B-series events through its oscillations. These oscillations pass through the system's "now" and are counted by electronic circuits to generate the system clock signal. Modern computers typically use Phase-Locked Loops (PLLs) to multiply this base frequency to generate the much higher frequencies needed for CPU operation (in the gigahertz range). This demonstrates both B-series relations (the fixed ratios between crystal oscillations and CPU clock cycles) and A-series progression (as each cycle becomes present then past in the system's "now").

At the software level, these hardware clock signals are abstracted into system time, where the operating system maintains both a monotonic clock (pure B-series time showing intervals between events) and a wall clock (which incorporates A-series time by synchronizing with external time sources). The system timer interrupt handler increments counters at regular intervals, creating a discrete series of timestamps. Software can access both types of time: the monotonic clock for measuring durations (B-series) and the wall clock for absolute timestamps (A-series). Modern programming languages and APIs explicitly recognize this duality by providing separate functions for each (e.g., in JavaScript, Date.now() for wall time and performance.now() for monotonic time).

This hardware and software timing duality manifests directly in YouTube's search interface through its two temporal parameters. The "upload date" parameter represents A-series time - it references when videos were uploaded relative to the present moment ("within last hour", "today", "this week", etc.). This constantly shifts as new moments become present then past. The "duration" parameter represents B-series time - it measures the fixed interval between the start and end points of each video, maintaining unchanging earlier/later relations. These two parameters cannot be reduced to a single temporal dimension because they reflect the fundamental dual nature of time that exists from the hardware level up through the entire computing stack.

The hardware-level clocks and software-level clocks are intimately connected through a layered system of translations. At the lowest level, the quartz crystal oscillator generates B-series events (crystal state transitions) that pass through the system's "now." These oscillations are counted and scaled by the hardware timer circuits to generate regular interrupt signals to the CPU. The operating system's interrupt handler then processes these signals to maintain two distinct software time tracking systems: the monotonic clock that counts pure intervals (B-series) and the wall clock that tracks real-world time (A-series). The wall clock can be adjusted based on network time protocols to maintain synchronization with external time sources, while the monotonic clock continues counting steadily from system start, immune to such adjustments. This shows how the hardware oscillations are transformed into both B-series and A-series representations at the software level.

It would not be possible to have just one temporal parameter at the hardware level while maintaining two at the software level, because the dual nature of time is fundamental and cannot be derived from a single series alone. The paper argues that if B-series time were truly fundamental, we should be able to derive A-series properties from it - but this is impossible, as demonstrated by the YouTube UI example. Even if we tried to build software clocks using only the B-series hardware oscillations, we would still need some way to establish "now" and track how events become present then past. The hardware oscillations themselves inherently involve both series - they have fixed earlier/later relations between states (B-series) but also must pass through the system's present moment (A-series). The software level merely makes explicit this dual nature that already exists in the hardware.

The progression from hardware clocks to software time parameters reveals the inherent duality of A-series and B-series time. At the hardware level, computers use crystal oscillators, typically vibrating at 32,768 Hz, which establish the fundamental B-series relations of earlier/later states. These oscillations flow through the system's "now," with electronic circuits counting transitions to generate the system clock signal that coordinates all computer operations.

This hardware timing gets abstracted into the operating system's time management through a hierarchy of software clocks. The system timer interrupt handler increments counters based on crystal oscillations, maintaining both absolute time (synchronized with external time sources) and relative time intervals. The operating system must track both when events occurred relative to "now" (A-series) and the duration between events (B-series), as these serve different purposes in process scheduling, file timestamps, and network protocols.

Programming languages and frameworks further abstract these timing concepts into high-level constructs. For instance, JavaScript's Date object maintains both absolute timestamps (milliseconds since January 1, 1970) and methods for calculating durations. Web APIs like requestAnimationFrame() deal with both scheduling relative to "now" and maintaining fixed frame intervals. Database systems must handle both transaction ordering (B-series) and temporal validity of data relative to the current time (A-series).

This dual nature of computational time manifests clearly in user interfaces like YouTube's video search. The video duration parameter represents fixed B-series relations between timestamps within each video. The upload date parameter represents when videos entered the system's "now," becoming present then past - a pure A-series concept. The hardware's oscillating crystal could not, by itself, generate this distinction. The two parameters emerge from how software systems must model both aspects of time to be useful.

This duality extends through the entire software stack. Version control systems track both commit timestamps (A-series) and sequential ordering (B-series). Cache systems need both absolute expiration times and relative time-to-live values. Network protocols require both absolute timestamps for synchronization and relative delays for timing out. Game engines must handle both absolute game time and frame durations. Even simple animations need both start times and durations.

The software cannot derive one temporal series from the other because they serve fundamentally different purposes. The upload date allows users to find recent content relative to their "now," while duration lets them gauge time commitment regardless of when the video was uploaded. These distinct temporal concepts emerge naturally from how humans interact with digital systems, reflecting the underlying reality that time has both A-series and B-series aspects that cannot be reduced to each other.

It would not be possible for the hardware to have one parameter but the software to have the two parameters. This follows directly from the A-theory's falsifiability claim. Since the hardware clock provides the fundamental time source for all software operations, it must contain both A-series and B-series aspects for the software to access them.

The hardware's crystal oscillator demonstrates this - it has both fixed B-series relations between oscillation states and the passage of these states through the system's "now" (A-series). The software cannot generate a second temporal series that wasn't present in its underlying hardware timing source. The two parameters in software interfaces like YouTube's search reflect the dual temporal nature already present in the hardware clock.

This highlights why the A-theory prediction is falsifiable - if B-series alone were sufficient, we should be able to find systems (starting at the hardware level) that successfully operate with just one temporal parameter. The fact that we cannot, even at the most fundamental hardware level, supports the A-theory claim that both series are ontologically necessary.

For a hardware clock operating with both temporal series, we define the relationships between hardware and software timing parameters:

Hardware to Software B-series (seconds): $t_{software} = k * t_{hardware}$ where k is a constant scaling factor (typically 1 for direct correspondence)

Hardware to Software A-series (elementary temporal experiences): $\tau_{software} = m * \tau_{hardware}$ where m is a constant mapping between hardware and software temporal experiences

We perform two cross-checks of these equations. First, both equations maintain proper dimensional consistency throughout their transformations. They also preserve the fundamental properties of their respective temporal series, ensuring that the essential characteristics of both A-series and B-series time remain intact. The scaling factors k and m provide flexibility in granularity while maintaining these essential temporal relationships.

For our second cross-check, we observe that the equations properly respect the independence of A-series and B-series time. The linear relationships established by these equations preserve the crucial ordering properties within each series. Importantly, each transform operates strictly within its own temporal series ($t \to t$, $\tau \to \tau$), with no cross-mixing between A-series and B-series parameters, maintaining the distinct nature of each type of time.

These equations formalize how software inherits both temporal series from hardware while allowing for different scales and representations appropriate to each level.

References

in progress