THE PHILOSOPHY OF SUPERDETERMINISM SUPPORTED BY TIME DILATION

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The philosophy of superdeterminism is based on a single scientific fact about the universe, namely that cause and effect in physics are not real. Time dilation is a phenomenon in physics, specifically in Einstein's theory of relativity, where time passes at different rates for observers who are in relative motion or who are in different gravitational fields. Experimental evidence verifies that time dilation can affect radioactive decay rates. Individual radioactive decay events being inherently random are fundamentally uncaused meaning lacking a deterministic prior trigger. If one counted the decay events in two equally weighted blocks of the same radioactive elements that were isotopically similar, where one block remains stationary and the other is sent out at high speed in a rocket ship, over time the number of decay events for the stationary block would significantly exceed the number of decay events for the moving block due to time dilation. The effect of the two radioactive blocks possessing different numbers of decay events is not the result of any physical causal interaction. The presence of probabilistic events within a moment of time (like radioactive decay) creates a logical contradiction, if the present moment is solely responsible for causing the next moment in a deterministic way. Within the framework of a predetermined static block universe, the contradiction dissolves because the future is already determined and the relationship between temporal slices is not one of cause and effect in the sense of observable physical interactions.

The philosophy of superdeterminism is based on a single scientific fact about the universe, namely that we live in a predetermined static block[1] universe without cause and effect in physics. Time dilation is a phenomenon in physics, specifically in Einstein's theory of relativity, where time passes at different rates for observers who are in relative motion or who are in different gravitational fields. In simpler terms, two identical clocks that are moving relative to each other or are positioned differently in a gravitational field will not measure the same elapsed time between two events. Time dilation has been experimentally verified using atomic clocks and airplanes.

In 1971, physicists Joseph Hafele and Richard Keating took highly accurate cesium-beam atomic clocks on commercial airplanes that flew around the world twice, once eastward and once westward.[2] They compared the time recorded by these traveling clocks with identical clocks that remained stationary at the U.S. Naval Observatory. The results showed a measurable difference in time between the clocks, and these differences were consistent with the predictions of both special and general relativity. The clocks on the eastward-flying plane lost a small amount of time (due to the combined effects of speed and gravity).[3] The clocks on the westward-flying

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[1] Imagine a cosmic four-dimensional block, where the three familiar dimensions of space (length, width, and height) are combined with a fourth dimension of time. Every single moment in history would occupy a specific location within this block. From this perspective, there is no special "now" moment that separates the past from the future. They all exist equally.

[2] Hafele, J.C. & Keating, Richard E. "Around-the-World Atomic Clocks: Predicted Relativistic Time Gains." Science Vol. 177, Issue 4044, pp. 166-168 (July 14, 1972).

[3] In terms of the Special Relativistic Time Dilation (Velocity Effect), the Eastward moving plane's velocity is in the same direction as the Earth's rotation. This means its speed relative to the Earth's center is *higher* than the speed of the stationary ground clocks. According to special relativity, a clock moving at a higher speed runs *slower*. So, the eastward-flying clock experienced a loss in time due to its increased velocity relative to the Earth's center. The Westward moving plane's velocity is in the opposite direction to the Earth's rotation. This means

plane gained a small amount of time (due to the interplay of speed and gravity in the opposite direction of Earth's rotation).[4] The observed time difference was the combination of the velocity and gravitational time dilation effects.[5]

Experimental evidence verifies that time dilation can affect radioactive decay rates.[6] The rate of muon decay in this experiment is inherently random.[7] Individual radioactive decay events being inherently random are fundamentally uncaused meaning lacking a deterministic prior trigger. If one counted the decay events in two equally weighted blocks of the same radioactive elements that were isotopically similar, where one block remains stationary and the other is sent out in a high speed spacecraft, over time the number of decay events for the stationary block would significantly exceed the number of decay events for the moving block due to time

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its speed relative to the Earth's center is *lower* than the speed of the stationary ground clocks. According to special relativity, a clock moving at a lower speed (compared to a faster clock) runs *faster* (or experiences less slowing). So, the westward-flying clock experienced a gain in time (or less loss of time) due to its lower velocity relative to the Earth's center.

[4] In terms of Gravitational Time Dilation, both the eastward and westward flying clocks were at a higher altitude than the stationary clocks at the U.S. Naval Observatory. According to general relativity, clocks at a higher gravitational potential (farther from the Earth's center) run faster than clocks at a lower gravitational potential (closer to the Earth's center). Therefore, both flying clocks experienced a gain in time relative to the ground clocks due to this gravitational effect.

[5] In simpler terms, the westward flight was effectively "slowing down" its speed relative to the Earth's rotation in the chosen inertial frame (approximately the Earth's center), which lessened the time-slowing effect of special relativity and allowed the time-gaining effect of general relativity (due to altitude) to become dominant. For the Westward flight, the time gain (or reduced loss) due to the lower velocity (special relativity) was greater than the time gain due to the higher altitude (general relativity), resulting in a net gain of time for the westward-flying clocks. For the Eastward flight, the time loss due to the higher velocity (special relativity) was greater than the time gain due to the higher altitude (general relativity), resulting in a net loss of time for the eastward-flying clocks.

[6] Frisch, David H. & Smith, James H. "Measurement of the Relativistic Time Dilation Using μ-Mesons." Am. J. Phys. 31, 342-355 (1963).

[7] Chico, J. et al. "Muon flux measurements and the randomness of the data: a project work for honours physics degree students." Latin-American Journal of Physics Education, Vol. 12, No. 3 (2018).

dilation.[8] The two blocks of radioactive elements can be returned to the same stationary position with the real effect that the blocks underwent significantly different numbers of decay events being isotopically dissimilar.[9]

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[8] To directly observe time dilation's effect on radioactive decay using a spacecraft achieving a peak speed similar to the Parker Solar Probe's 692,000 km/h (at its perihelion around the Sun), we would need two identical samples of a radioactive isotope with a sufficiently high activity and a half-life long enough to remain measurable over the multi-year experiment, such as Cobalt-60 (^{60}Co), which has a half-life of 5.27 years and decays by beta emission with a prominent gamma ray emission easily detectable by a Geiger counter. Two identical Geiger counter systems would be required. One ^{60}Co sample and detector would remain stationary in a controlled laboratory on Earth. The other identical setup would be placed aboard a spacecraft following a highly elliptical orbit with an approximately 88-day period, similar to the Parker Solar Probe, allowing it to reach peak speeds of 692,000 km/h during its closest solar approaches. Data collection would ideally focus on maximizing the time spent at high relative velocities to Earth. To accumulate enough decay events to potentially observe a statistically significant difference (at a 3σ level) arising from the peak time dilation factor of roughly 2.048×10−7, continuous data collection over multiple orbits, totaling an estimated 6.8 years of equivalent high-speed travel time relative to the Earth-based lab, would be necessary. Over this extended observation, the slightly slower passage of time on the spacecraft during its high-speed segments would theoretically result in a measurably lower cumulative number of ^{60}Co decay events detected compared to the stationary sample on Earth, assuming precise environmental control and accounting for the varying relative velocity throughout the orbit.

[9] A similar experiment using gravitational time dilation could be performed by placing the cobalt block and Geiger counter in a deep mine shaft. To investigate gravitational time dilation's influence on radioactive decay within a mine shaft, we would deploy two meticulously matched sets of equipment. Each set would comprise an identical radioactive sample (such as Cobalt-60), a shielded Geiger counter to detect the emitted radiation, and a precisely synchronized data logging system capable of recording the counts from the Geiger counter with accurate timestamps derived from a common time source like GPS at the experiment's initiation. One set would be positioned at the Earth's surface, serving as the control, while the other would be placed at a significant and consistent depth within a deep mine shaft (e.g., several kilometers). The experiment would run continuously for an extended duration, anticipated to be multiple years (potentially 5 to 10 years or more). Throughout this prolonged observation, the data loggers at both locations would diligently record the number of counts registered by their respective Geiger counters at frequent intervals. Concurrently, environmental conditions such as temperature, pressure, humidity, and background radiation levels at both the surface and the mine's depth would be meticulously monitored and recorded to identify and potentially account for any influences on the decay rates unrelated to time dilation. Upon completion of this multi-year data collection, a detailed statistical analysis would be performed to compare the total number of counts recorded by the Geiger counter at the surface versus the depth. A statistically significant and consistent difference in the cumulative counts, correlated with the predicted gravitational time dilation for the established depth difference over the long experimental period

A purely physical definition of cause and effect in physics focuses on how one physical event or entity influences another through direct physical interaction or the transfer of energy and momentum, leading to a predictable change in the state of the affected entity. There was no direct physical interaction between the radioactive blocks that caused the real effect that the blocks underwent significantly different numbers of decay events. The "cause" in this scenario is the difference in their relativistic conditions (relative velocity or gravitational potential), which affects the passage of time for each block individually, leading to the different observed decay rates. However, time dilation is a consequence of the relative velocity between two inertial frames and how observers in those frames measure the time intervals between the same events. Time dilation is not a direct cause-and-effect phenomenon in the sense of one object actively causing the other's time to slow down through a force or interaction at the moment of observation. Consequently, the effect of the two radioactive blocks possessing different numbers of decay events is not the result of any physical causal interaction.

Relative velocity does not exist at any point in space. Gravitational potential cannot be directly observed. And the differential passage of time can only be inferred from the change in physical phenomena. So, there is no physical observable interaction that causes the effect on the two radioactive blocks brought on by time dilation, because the changes in the rates of radioactive decay are not caused by physical observable interactions. The differential passage of time is not caused by any physical observable interactions. If the differential passage of time is not caused by any physical observable interactions, then the passage of time is not caused by any physical observable interactions. If the passage of time is not caused by any physical observable

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and after accounting for any identified environmental factors, would provide evidence for the subtle effect of gravity on the rate of radioactive decay, relying solely on the integrated measurement of decay events detected by the Geiger counters over an extended timeframe.

interactions, then time does not require cause and effect in physics defined in terms of observable physical interactions to be real.

Consequently, there is no good reason to say that the present moment of time must cause the next moment of time, such that the future moment of time does not yet exist.[10] If the present moment were the cause of the next moment, then all the physical entities and events within that present moment would presumably contribute to or determine the nature of the subsequent moment. For the present moment to cause the next, it would imply a deterministic link. However, the presence of probabilistic events within that moment (like radioactive decay) introduces inherent unpredictability. The present moment cannot simultaneously cause a specific deterministic future and also contain elements that lead to a range of probabilistic futures. This creates a logical contradiction if the present moment is solely responsible for causing the next moment in a deterministic way.[11] Within the framework of a predetermined static block

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[10] Because the present moment of time cannot cause the next moment of time, then the next moment of time must already exist in a hidden future dimension of time. Consequently, cause and effect in physics are not real, because otherwise the present moment of time would cause the next moment of time.

[11] Something that is uncaused cannot be caused. Time cannot cause an uncaused event. Time cannot therefore cause the slow down in the decay rate, because the decay rate is uncaused. If the present moment of time cannot cause the slow down in the decay rate, then the present moment cannot cause the next moment of time, because the next moment of time includes the slow down in the decay rate. The present moment cannot cause the next moment of time, which means that the next moment must already exist somewhere, because the present moment is not causing it to exist. Hence, the next moment of time must exist somewhere, which means it must exist in a hidden dimension of time. That means the future already exists in our predetermined static block universe. The decay events in this argument are useful, because only the slow down in time can possibly be responsible for the slow down in the uncaused rate of decay. The blocks have no physical interactions that could explain the slow down in the decay rates. The time variable is isolated as the cause of the slow down in the uncaused decay rate. The argument tells you something about the nature of time namely that the present moment of time does not cause the next moment of time.

Additionally, it is not possible for anything to move into the next moment of time, because something, such as a radioactive block, could not change the pre-existing next moment of time by moving into it due to the lack of cause and effect in physics. The mere presence of universe, the contradiction dissolves because the future is already determined and the relationship between temporal slices (hyperplanes of spacetime) is not one of cause and effect in physics in the sense of observable physical interactions.

something, such as a radioactive block, moving into the next moment of time would change the pre-existing next moment of time, which is impossible without cause and effect in physics. Because the next moment of time is already a pre-existing, fixed slice (hyperplane of spacetime) of the block universe, then the radioactive block in the present moment cannot *move into* it and thereby alter what was already there. The very act of moving into it implies a change in the configuration of that future moment due to the block's presence, which would require a form of causal influence.