Pre-ACES prediction paper,
is written in jun. 2026, therefore before the publication of the final ACES scientific results.

It presents a testable prediction concerning the future results of the ACES mission:

Clocks in space and on Earth tick at the same rate

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Abstract

The ACES mission compares the rate of clocks in space with clocks on Earth. According to the standard relativistic interpretation, a clock aboard the International Space Station should run at a slightly different rate from a clock on Earth.

But science must remain open to all possible outcomes of the experiment. If the measurements were to show that the clocks operate synchronously, such a result would raise important questions concerning our current understanding the propagation of electromagnetic signals.

In the following, we will focus on the measurement results, which are unexpected for many, where the clocks run synchronously. There is no need to justify the choice of such a result, because according to the ACES plan, the actual measurement result will follow soon.

Scientific progress depends not only on our ability to measure nature accurately, but also on our willingness to accept and examine the results, even when they differ from long-established expectations.

The ACES Mission

The Atomic Clock Ensemble in Space (ACES) is one of the most ambitious precision-measurement projects ever undertaken in space. Developed under the leadership of the European Space Agency (ESA) in cooperation with several international scientific institutions, the project was conceived to investigate some of the most fundamental questions concerning time, gravity, frequency, and the propagation of electromagnetic signals.

The origins of ACES can be traced back more than two decades, when advances in atomic-clock technology made it possible to measure time and frequency with unprecedented accuracy. Physicists recognized that placing highly stable atomic clocks in orbit would create an opportunity to compare the flow of time under different gravitational conditions with a precision never achieved before.

Picture 2 -The ACES clock was attached to the ISS station in April 2025.

The ACES payload was installed aboard the International Space Station (ISS), which orbits Earth at an altitude of approximately 400 km. The system contains two independent atomic clocks: PHARAO, a cold-atom cesium clock developed by the French space agency CNES, and the Space Hydrogen Maser (SHM), which provides exceptional short-term frequency stability. Together, these clocks form one of the most accurate timekeeping systems ever operated in space.

A central component of the mission is the Microwave Link (MWL), that enables the comparison of clock frequencies between the ISS and multiple ground stations distributed around the world. By continuously exchanging precisely timed signals between Earth and orbit, ACES allows researchers to compare the frequencies of atomic clocks separated by large distances and different gravitational potentials.

The primary scientific objective of ACES is to test predictions of Einstein's theory of relativity with significantly higher precision than previously possible. Following installation on the ISS, the ACES instruments entered an extended phase of commissioning, calibration, and verification. Such procedures are unavoidable in experiments operating at the limits of current measurement technology or where the measurement results do not coincide with fundamental physical knowledge.

The official goals of ACES are ambitious, but the potential implications of the experiment may be even broader. Any result confirming existing relativistic predictions would further strengthen confidence in current physical models. Conversely, any unexpected discrepancy would motivate careful re-examination of assumptions concerning gravitational effects, clock synchronization, and electromagnetic signal propagation. For this reason, ACES is widely regarded as one of the most important space-based physics experiments of the present decade.

According to relativistic theoretical expectations, a clock aboard the International Space Station should differ from an identical clock on Earth by approximately several microseconds per day due to the combined effects of gravity and orbital motion. The Classical Model developed in this article predicts that the two clocks will run synchronously, are increasingly likely and expected, and the mission and goals of the project are expanding.

If ACES measurements demonstrate that the clock aboard the ISS and the clock on Earth run synchronously, with neither clock systematically gaining or losing relative to the other, the implications become far-reaching. Such a result raises fundamental questions.

Many experiments traditionally regarded as confirmations of relativity admit alternative interpretations. In some cases, the same experimental observations can be viewed either as support for relativity or as support for a Classical Model of Light. It will be confirmed or refuted by the direct results of the ACES measurement when they are published.

For this reason, the ACES project of the European Space Agency may have exceptional importance. By directly comparing highly precise atomic clock frequencies between Earth and the International Space Station, ACES could provide one of the clearest experimental opportunities so far for examining how gravity influences time. The experiment therefore has the potential not only to test existing interpretations, but also to motivate renewed discussion about the physical meaning of some of the most fundamental concepts in modern physics.

Classical Model - the alternative to the theory of relativity

If ACES measurements were to demonstrate synchronous clock rates, such results would be difficult to reconcile with current relativistic predictions and could motivate consideration of alternative model - C*lassical Model* - in which the measurement results will be understandable. In its simplest form, the Classical Model assumes that space and time are absolute and that light leaves its source with velocity c. Ether is not assumed to exist. The model further assumes that motion of the observer influences the observed frequency of electromagnetic waves through Doppler-like effects, while wavelength remains unaffected.

If the observer moves toward the source, the received signal velocity becomes c+v; if the observer moves away from the source, it becomes c−v. The model therefore differs fundamentally from the relativistic interpretation, where the velocity of light remains c relative to all observers regardless of source or receiver motion. If ACES measurements were to support synchronous clock rates, the Classical Model could provide a framework for interpreting such results.

In that case, some gravitational shifts observed in earlier spectroscopic experiments might need to be interpreted that gravity affects the wavelength of light, but not its frequency. This possibility opens a broader question concerning the relationship between frequency, wavelength, and the propagation of light itself. In conventional physics, frequency and wavelength are usually treated as directly connected through the constant speed of light. Here we allow the possibility that physical conditions such as gravity or motion might influence frequency and wavelength differently and, under some circumstances, even independently.

This differs from many earlier measurements of gravitational shifts, in which frequency and wavelength were often not treated independently. In spectroscopic measurements, frequency is generally inferred from wavelength together with the assumed speed of light. However, if frequency and wavelength of electromagnetic waves could vary independently, some earlier interpretations might need to be reconsidered.

Indications compatible with aspects of the Classical Model may already exist in several earlier experiments. But, some potentially important questions have remained unresolved or insufficiently examined. Some experiments may not have received sufficient attention because their results did not fit established interpretations of physical phenomena.

If ACES shows unchanged signal frequencies between the ISS and Earth, this will raise the question of whether gravitational effects observed in some earlier experiments may primarily influence wavelength rather than directly affecting the frequency of electromagnetic waves. In answering this question, the ACES measurement will play a key role. ACES could provide one of the clearest opportunities so far to distinguish between different views on the propagation of light.

Verification and Interpretation of ACES Results

The development of physics is typically gradual. Most advances result from improvements in measurement accuracy, refinement of theoretical models, and increasingly precise interpretation of experimental observations. Occasionally, however, experiments emerge whose implications extend far beyond their original technical objectives. Such experiments may challenge assumptions that have remained largely unquestioned for decades. The ACES mission may represent one such case.

Because ACES compares atomic clock frequencies between Earth and orbit with unprecedented precision, even small deviations from current theoretical expectations could have significant scientific consequences. For this reason, any unexpected result would require exceptionally careful examination before firm conclusions could be drawn. Discussions concerning possible alternatives therefore often become sensitive.

The process of scientific validation extends far beyond the initial measurement itself. Instrument calibration, assessment of systematic uncertainties, independent replication, and detailed analysis of signal propagation effects are essential steps in establishing confidence in the results.

This requirement applies equally to all possible outcomes of the experiment. Confirmation of current relativistic predictions would further strengthen existing theoretical models. Conversely, results inconsistent with present expectations would motivate renewed examination of assumptions concerning gravitational effects, clock synchronization, frequency transfer, and electromagnetic propagation.

History shows that scientific paradigms do not change immediately in response to a single measurement. New interpretations generally require repeated verification, complementary experiments, and extended scientific discussion. This is particularly true for concepts that have become deeply integrated into modern technology, education, and scientific intuition.

For this reason, the eventual interpretation of ACES results may prove to be as important as the measurements themselves. The scientific value of the mission lies not only in its extraordinary precision, but also in its potential to reduce interpretational ambiguity and to provide a clearer experimental basis for evaluating competing explanations of gravitational frequency shifts and clock synchronization.

Whatever the outcome, ACES is expected to contribute significantly to our understanding of time, gravity, and electromagnetic propagation. Its greatest importance may lie in its ability to encourage open scientific discussion guided by experimental evidence rather than by theoretical preference.

Conclusion

The ACES project has exceptional scientific importance. Unlike many earlier experiments, ACES is based on the direct comparison of highly stable atomic clock frequencies transmitted between Earth and orbit through a microwave link. Such measurements reduce the role of assumptions and therefore offer a comparatively direct test of how gravity influences clock frequency.

If ACES measurements demonstrate synchronous clock rates between clocks on the ISS and clocks on Earth, this would represent an important challenge for current interpretations of gravitational frequency shifts. Such a result would not necessarily invalidate relativity as a whole, but it could require a substantial reinterpretation of some relativistic phenomena and of the relationship between frequency, wavelength, and the propagation of light.

At the same time, such conclusions could not be accepted immediately. Because relativity forms one of the central conceptual structures of modern physics, any result suggesting an alternative interpretation would require extremely careful verification, repeated ACES measurements, possible extensions of the experiment, additional complementary experiments, and renewed analysis of earlier measurements would all be necessary before broad scientific acceptance could emerge.

If future experiments were eventually to confirm the independent behavior of frequency under certain physical conditions, this could lead not merely to a correction of existing theories, but to a broader shift in scientific understanding of light, gravity, and electromagnetic propagation. In this sense, ACES may become one of the most important experiments of contemporary physics and ACES measurements would exceed expectations.