Proposal: H-Units — A Universal, Hydrogen-Anchored Standard for Time and Length

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Abstract

This paper proposes H-Units, a new system of time and length designed for an increasingly multi-planetary future. The H-second is defined as exactly 1,500,000,000 cycles of the hydrogen hyperfine transition (the 21-cm line), yielding $\approx$1.056036 s. The H-meter is defined such that the speed of light equals exactly 300,000,000 H-meters per H-second, yielding $\approx$1.055306 m. Notably, this produces the elegant result that the hydrogen hyperfine wavelength equals exactly 20.000 H-cm.

Unlike the SI system, whose second and meter ultimately trace back to Earth's rotation and size, H-Units are derived solely from universal constants. H-Units restore a more natural logical ordering—time defined first, distance derived from light—and provide a practical, Earth-independent framework suitable for interplanetary navigation and precision metrology.

1 Motivation: The Need for a Universal Standard

As humanity prepares for permanent settlements on the Moon, Mars, and beyond, our current system of units reveals a fundamental limitation: it remains subtly anchored to Earth. An Earth-centric time and length standard creates unnecessary complexity for coordination, navigation, scientific data comparison, and long-term operations across different planetary bodies.

2 History of the Current SI Definitions

The division of time into hours, minutes, and seconds has deep historical roots. Over 4,000 years ago, the Babylonians developed a sexagesimal (base-60) numbering system for astronomy and timekeeping. This system influenced later civilizations and eventually led to the division of the day into 24 hours, each hour into 60 minutes, and each minute into 60 seconds.

For most of recorded history, the second was defined astronomically as 1/86,400 of a mean solar day. In 1956, it was redefined as a fraction of the tropical year 1900 (the "ephemeris second"). In 1967, the 13th General Conference on Weights and Measures adopted the atomic definition: the second is exactly 9,192,631,770 cycles of the cesium-133 hyperfine transition. This specific number was deliberately chosen so the new atomic second would match the length of the previous Earth-based ephemeris second as closely as possible.

The meter was originally defined in 1799 based on the size of the Earth, with physical platinum bars serving as the legal standard. In 1960, it was redefined using the wavelength of krypton-86 because physical metal bars were subject to wear, thermal expansion, and slight variations between prototypes, while a spectral line offered far greater reproducibility and precision. In 1983, the 17th General Conference on Weights and Measures decreed that the speed of light in vacuum is exactly 299,792,458 meters per second. The specific value was chosen to preserve continuity with the existing prototype, not because it represented a more fundamental physical constant.

In both cases, the numerical values of the constants were adjusted to fit pre-existing Earth-based units, rather than allowing universal constants to define the units from first principles.

3 The H-Unit Proposal

H-Units reverse this approach, allowing a universal atomic constant to define the unit of time, with length then derived from light propagation over that interval.

Hydrogen is the simplest and most abundant element in the universe. Its ground-state hyperfine transition (the famous 21-cm line) is a sharp, stable spectral feature that is observable anywhere in the cosmos with basic radio equipment.

The hydrogen hyperfine transition frequency has been measured to high precision as:

$$\nu_H = 1{,}420{,}405{,}751.768 \text{ Hz}$$

The H-second is defined as exactly 1,500,000,000 cycles of this frequency. This scaling was chosen deliberately because it:

- Produces an H-second of approximately 1.056036 SI seconds, keeping it close to the familiar human experience of time.
- Results in the hydrogen hyperfine wavelength equaling exactly 20.000 H-cm.

From this clean definition of time, the H-meter is then derived naturally:

$$1 \text{ H-m} \equiv \text{the distance light travels in vacuum in exactly } \tfrac{1}{300{,}000{,}000} \text{ of an H-second}$$

It follows directly that the speed of light is exactly 300,000,000 H-meters per H-second—not by decree, but as a natural consequence of the definition.

4 Key Advantages of H-Units

H-Units offer several significant advantages as a universal standard for the space age:

- **True Universality:** The H-second is based on hydrogen, the most abundant element in the universe, making it independent of any specific planet's motion or history.
- **Logical Consistency:** Time is defined first from a fundamental constant, and length is then cleanly derived from the speed of light—restoring the natural physical order.
- **Numerical Elegance:** The chosen scaling produces clean, round numbers, most notably making the hydrogen hyperfine line equal exactly 20.000 H-cm.
- **Practical Compatibility:** Because the H-second is only about 5.6% longer than the SI second, it maintains close compatibility with existing human intuition and engineering practices, though straightforward conversion factors apply when working between the two systems.

H-Units require no new hardware. The existing global network of cesium atomic clocks, as well as modern optical lattice clocks and other standards, can realize the H-second through the well-established frequency ratio between the cesium and hydrogen transitions, using the same frequency-ratio measurement techniques already employed in modern metrology.

Like SI, H-Units define a coordinate time standard; relativistic corrections between planetary reference frames apply in the usual way.

5 Applications and Use Cases

H-Units are particularly well-suited for the challenges of a multi-planetary civilization.

On Mars, where a solar day (sol) lasts 24 hours and 39 minutes, colonists will naturally adopt local solar time for daily human rhythms. However, scientific data collection, geological sampling, rover navigation, mission planning, and coordination with Earth would benefit from a single, stable universal time reference that does not drift relative to other locations.

For deep space missions, H-Units provide a consistent reference frame that remains identical whether a spacecraft is near Earth, on Mars, or traveling to the outer solar system. This eliminates the need for complex, error-prone time unit conversions across mission phases.

In long-term scientific research, geological records, climate data, astronomical measurements, and communication protocols can all be timestamped and expressed using one universal standard.

H-Units are designed to serve as a parallel universal standard alongside SI—much like how UTC serves as a global reference while local time zones continue for everyday life on Earth.

6 Conclusion

H-Units offer a cleaner, more logically consistent, and truly universal foundation for time and length as humanity becomes a multi-planetary species.

By anchoring the fundamental unit of time to the hyperfine transition of hydrogen—the most abundant element in the universe—and deriving length directly from the speed of light, H-Units eliminate the historical compromises and circular dependencies that remain embedded in the current SI system. The chosen scaling factors produce clean integer relationships while maintaining practical compatibility with existing human time perception.

As we establish permanent settlements on the Moon, Mars, and eventually beyond, a truly universal metrological framework will become increasingly valuable. H-Units provide that framework—a simple, elegant, and practical standard that complements rather than replaces SI, giving humanity a common scientific language wherever we go in the solar system and beyond.

References

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