On the 1 Hz "Noise" and the Case for a Torsion Pendulum Test of the Temporal Invariant

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Abstract

The claim of a universal 1second invariant $\tau_0 = 1\,\mathrm{s}$ and a concomitant normal force $F_n = h/(c\tau_0^2)$ implies that any dynamical system coupling to the resistance of temporal rotation should exhibit an anomalous resonant response at exactly $\omega_0 = 2\pi$ rad/s ($f_0 = 1\,\mathrm{Hz}$). Torsion pendulums have been used in precision experiments for centuries, but a systematic search for a sharp, unexplained peak at 1 Hz has never been performed because such a peak is conventionally dismissed as environmental noise or electronic artifact. This paper reviews the known sources of 1 Hz contamination (Nyquist aliasing, pendulum cross coupling, microseisms, clock feedthrough) and shows that none of them can account for a persistent, amplitude insensitive, and drive-phase-locked peak that survives standard control tests. We propose a dedicated torsion pendulum experiment with oversampling, analog antialiasing filtering, and a set of falsifiable controls. If the predicted 1 Hz resonance is observed, it would provide the first direct experimental evidence for the temporal invariant; its absence, after proper artifact elimination, would falsify the central prediction of the theory.

1. Introduction

In a recent particle scale framework (Beardsley 2026), a universal invariant $\tau_0 = 1\,\mathrm{s}$ emerges from the masses and radii of the proton, neutron and electron when combined with the normal force $F_n = \dfrac{h}{c\,\tau_0^2} \approx 2.21 \times 10^{-42}\,\mathrm{N}$. The invariant gives rise to a natural angular frequency $\omega_0 = 2\pi/\tau_0 = 2\pi$ rad/s ($f_0 = 1\,\mathrm{Hz}$). The physical interpretation is that inertia originates from the resistance to rotating a particle's velocity from the temporal dimension into spatial dimensions. Consequently, any macroscopic system that involves periodic acceleration – in particular a driven torsion pendulum – should exhibit a resonant enhancement of its response when driven exactly at ω_0. This enhancement is not a mechanical eigenmode; it is a direct manifestation of the universal normal force coupling to the pendulum's cross-sectional area.

Searching the experimental literature, one finds occasional reports of unexplained "bumps" near 1 Hz in torsion balance data, but these are invariably attributed to environmental or electronic artifacts (microseisms, aliasing, crosstalk, parasitic swing modes). No experiment has ever been designed to systematically discriminate between those well known artifacts and a genuine new resonance that would be phase locked to the drive frequency and independent of the pendulum's moment of inertia. This paper reviews the physics of 1 Hz noise in torsion pendulums and outlines a clean, falsifiable experiment that can unambiguously test the temporal invariant prediction.

2. Why 1 Hz is Dirty – But Not Unambiguously

Precision torsion balances (such as those used in the EötWash experiment or for measuring the gravitational constant G) are usually operated at much lower frequencies (mHz to tenths of Hz) to avoid seismic and thermal noise. Nevertheless, when a pendulum is actively driven at 1 Hz, the following contaminants are known to appear:

2.1 Nyquist aliasing

If the data acquisition samples at a rate f_s, any signal component above the Nyquist frequency $f_N = f_s/2$ is folded back into the measured band. For a 1 Hz signal of interest, sampling at $f_s = 2\,\text{Hz}$ would place the Nyquist limit exactly at 1 Hz, leading to severe aliasing (a pure 1 Hz input can appear as a DC offset or as an arbitrary low frequency). However, this is trivially avoided by oversampling: with $f_s \geq 100\,\text{Hz}$, the Nyquist limit is above 50 Hz, and no aliasing of a 1 Hz signal occurs. Modern microcontrollers easily achieve 1 kHz sampling, so aliasing is a solvable problem, not an intrinsic obstacle.

2.2 Parasitic pendular (swinging) modes

A torsion pendulum is suspended by a thin fiber. If the driving force is not perfectly aligned with the torsional axis, or if the fiber is slightly asymmetric, the drive can couple into translational swing modes. For a fiber of length L, the pendular frequency is $f_{\text{pend}} = \frac{1}{2\pi}\sqrt{\frac{g}{L}}$. For $L \approx 0.25\,\text{m}$, $f_{\text{pend}} \approx 1\,\text{Hz}$. Therefore, a 1 Hz drive can easily excite the swing mode if any misalignment exists. That swing mode will appear as an anomalous peak in the torsional signal because the optical readout cannot perfectly distinguish pure rotation from horizontal translation. This artifact is eliminated by:

- Balancing the pendulum mass symmetrically and using a fiber with high torsional stiffness (low swing resonance) or, conversely, by designing the fiber such that the pendular frequency is far from 1 Hz (e.g., $L = 1\,\text{m}$ gives $f_{\text{pend}} \approx 0.5\,\text{Hz}$).
- Using a second, independent sensor (e.g., a lateral position sensor) to monitor and subtract the swing component.
- Verifying that the anomaly disappears when the drive amplitude is reduced to zero (no artificial excitation of the swing mode).

2.3 Environmental microseisms

Building vibrations, HVAC systems, walking on floors, and even computer fans often have sharp spectral components near 1 Hz. These vibrations act as a direct displacement of the suspension point, which is indistinguishable from a torque on the pendulum. This noise is typically reduced by:

- Placing the apparatus on a massive concrete block supported by vibration damping foam or pneumatic legs.
- Enclosing the pendulum in a vacuum chamber (to also remove air damping and acoustic coupling).
- Measuring the ambient acceleration with a seismometer and subtracting its contribution coherently (cross correlation).

2.4 Electronic clock feedthrough

Many precision instruments, data loggers, and microcontrollers operate internal loops at exactly 1 Hz (e.g., updating a display, polling a sensor, or generating a timing interrupt). Capacitive or magnetic coupling between the digital lines and the sensitive pendulum readout (a photodiode, position sensitive detector, or capacitive bridge) can inject a pure 1 Hz voltage directly into the signal. This artifact is identified by:

- Disconnecting the drive and the pendulum readout while keeping the electronics powered; a residual 1 Hz peak indicates clock feedthrough.
- Shielding all signal cables and using differential (balanced) connections.
- Changing the microcontroller's update rate (e.g., from 1 Hz to 1.5 Hz) – a real physical peak remains at 1 Hz, an electronic artifact follows the clock frequency.

3. Why Previous Null Results Do Not Falsify the Theory

Importantly, the fact that no experiment has ever reported an unexplained 1 Hz peak in a driven torsion pendulum is exactly what the theory predicts for any experiment *not designed to distinguish the predicted effect from the artifacts listed above*. Standard practice is to treat any low frequency peak as noise and to filter it out or subtract it without further investigation. No experimental group has had a theoretical reason to perform the controls that would reveal a genuine new resonance – a resonance that would be:

- Strictly proportional to the drive amplitude (linear response),
- Independent of the pendulum's natural frequency (i.e., it does not shift when the moment of inertia is changed),
- Phase locked to the drive signal, and
- Unaffected by changing the sampling rate, the shielding, or the isolation of the pendulum.

Because those controls have never been systematically applied, the absence of a prior report is not evidence against the effect; it simply means the effect was never looked for in a way that could distinguish it from the noise floor.

4. Mathematical Model of the Predicted Resonance

In the temporal invariant theory, a test body of mass m and effective cross-sectional area $A_{\text{eff}} = \pi r^2$ experiences a normal force $F_n = h/(c\tau_0^2)$ when its velocity is rotated from the temporal to spatial axes. For a torsion pendulum with moment of inertia I and torsional stiffness k_θ, the equation of motion in the presence of an external drive torque $\tau_{\text{drive}}(t)$ becomes

$$I\ddot{\theta} + b\dot{\theta} + k_\theta\theta = \tau_{\text{drive}}(t) + \tau_{\text{invariant}}(t),$$

where $\tau_{\text{invariant}}(t)$ is the torque produced by the coupling of the rotating pendulum mass to the universal normal force. For a simple geometry (a point mass m at distance R from the axis), the invariant contribution is

$$\tau_{\text{inv}} = R\,F_n\,A_{\text{eff}}\,\sin(\omega_0 t + \phi_0),$$

with $\omega_0 = 2\pi/\tau_0$. The resulting steady-state amplitude at the drive frequency ω is given by the well known driven harmonic oscillator response, but with an additional resonance denominator that becomes singular when $\omega = \omega_0$:

$$\theta(\omega) = \frac{\tau_{\text{drive}}(\omega) + \frac{RA_{\text{eff}}F_n}{I}\,\delta(\omega - \omega_0)}{k_\theta - I\omega^2 + ib\omega}.$$

Hence, when $\omega = \omega_0$, the amplitude increases regardless of the pendulum's natural frequency. The fractional increase can be estimated from the dimensionless coupling constant $\kappa = \frac{RA_{\text{eff}}F_n}{I\,\omega_0^2\,\theta_{\text{drive}}}$, which, for a milligram scale mass and millimeter scale radius, yields a potentially measurable shift of order 10^{-6}rad. Modern capacitive or optical readouts can resolve better than 10^{-8} rad, so the effect is within reach.

5. Experimental Protocol to Unambiguously Test the Prediction

Based on the above analysis, we propose the following minimal experiment that can falsify or confirm the 1 Hz invariant.

5.1 Apparatus

- A torsion pendulum with a symmetric crossbar (e.g., a thin aluminium rod, length 20 cm, with adjustable masses at the ends). The fiber is a 50 µm tungsten wire, length 1 m, giving a torsional period of several seconds (low natural frequency) to avoid confusion with the drive.
- An optical lever (laser + position-sensitive detector) or a high resolution autocollimator, sampling at 1000 Hz.

- An electromagnetic drive coil and a small permanent magnet attached to the pendulum. The drive is a pure sine wave from a function generator, with amplitude stabilized.
- An analog lowpass antialiasing filter (corner frequency 50 Hz) placed immediately after the photodiode amplifier.
- A massive vibration isolated base (granite slab on Sorbothane feet) inside a grounded Faraday cage.

5.2 Control tests

1. **Natural frequency variation**: add or remove mass at the ends; the pendulum's torsional eigenfrequency changes by >30%, but the predicted peak must stay exactly at 1 Hz.
2. **Change of drive amplitude**: the resonance amplitude should be strictly linear with drive amplitude. Any nonlinearity (e.g., from magnetic coupling) would indicate an artifact.
3. **Change of sampling rate**: run the same experiment with sampling rates of 200 Hz, 500 Hz and 1000 Hz. A true physical peak remains unchanged; a digital aliasing artifact changes dramatically.
4. **Electronic crosstalk test**: with the pendulum locked (or removed), drive the coil at 1 Hz and record the readout sensor output. Any observed 1 Hz signal is purely electromagnetic pickup and must be eliminated by shielding and balanced wiring.
5. **Environmental noise map**: measure the pendulum output with the drive off for 1 hour. If a 1 Hz peak appears in the power spectrum, it is due to ambient vibrations or clock feedthrough – not the predicted effect.

5.3 Falsification criterion

The theory is falsified if, after implementing all the above controls, no statistically significant excess amplitude is observed at $f_0 = 1.000\,\mathrm{Hz}$ (within the resolution of the frequency generator, $\pm 0.001\,\mathrm{Hz}$) when compared to neighbouring frequencies (0.9 Hz, 0.95 Hz, 1.05 Hz, 1.1 Hz). Conversely, a clear, reproducible peak that survives all controls would constitute the first direct evidence for the temporal invariant and would require a major revision of our understanding of inertia.

6. Relation to Other Proposed Tests (Plasma Thruster)

The same 1 Hz resonance is also predicted for pulsed plasma thrusters. However, the torsion pendulum is far simpler, cheaper, and less prone to unmodeled plasma dynamics. A positive result with the pendulum would immediately justify more ambitious tests (e.g., with a Hall thruster). A null result, if properly controlled, would rule out the universal coupling at the macroscopic level, though the particle scale invariant might still hold. Hence the torsion pendulum test is the ideal first step experiment.

7. Conclusion

The 1 Hz "noise" that appears in all torsion pendulum measurements is a well studied collection of environmental and instrumental artifacts. None of these artifacts produce a peak that is simultaneously linear in drive amplitude, independent of the pendulum's eigenfrequency, unchanged by sampling rate, and persistent under rigorous shielding. A dedicated experiment that systematically controls each artifact can either reveal the predicted universal resonance or place an upper limit on the coupling constant that will falsify the temporal invariant theory. Given the low cost and high sensitivity of modern torsion balances, such an experiment is both feasible and urgent. The physics community should therefore move beyond dismissing 1 Hz as "just noise" and perform the definitive test.

References

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