Attacking the No-Go: Assumption Audit and the Surviving Corner
A Working Note

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Abstract

The α_{eff} window note concluded that ACT's universal channel is not laboratory-detectable. This note attacks that conclusion systematically, auditing every assumption the no-go rests on. Three attacks fail in instructive ways, hardening the no-go into near-theorem status for any *natural* channel: (i) non-Gaussian statistics cannot decouple decoherence from momentum disturbance (information–disturbance bound); (ii) a perfectly uniform universal field is pure gauge—it can no more dephase a molecule against its gratings than it can deflect an accelerometer; (iii) band-limiting and Doppler arguments fail because random-walk force noise is white down to DC, so no spectral reshaping hides momentum diffusion from low-frequency accelerometry. One attack partially succeeds: the no-go assumed a relativistic field, for which frequency and correlation length are locked ($\xi \sim c/\omega$). A *non-relativistic medium* breaks the lock, and its most protected version—a medium comoving with the laboratory frame, with sub-micron correlation length—is bounded not by LISA Pathfinder but by atom interferometry, through the transfer law $\Gamma \propto M^2/v$. The numbers: $\Gamma_{\text{C}_{60}} \lesssim 0.02\ \text{s}^{-1}$ (still 30× below detection: the C_{60} program remains closed), but $\Gamma \lesssim 4\text{–}11\ \text{s}^{-1}$ for 10^4 amu species—an order of magnitude of genuine discovery space for next-generation heavy-molecule interferometry. The corner is theoretically expensive (Lorentz violation, a preferred local frame, drag fine-tuning, and LISA Pathfinder excludes its simplest variants) and is stated here with its full cost ledger. Its value is that it converts the no-go's survivor into three sharp signatures: M^2 mass scaling, $1/v_{\text{beam}}$ velocity dependence, and orientation anisotropy—each testable on existing platforms.

1 Strategy

A no-go theorem is attacked at its assumptions. The window note assumed: (A1) Gaussian noise statistics; (A2) the channel dephases through spatial field variation (gradient coupling); (A3) an unbounded, effectively flat spectrum at low frequency; (A4) a relativistic field, locking temporal frequency to spatial correlation length via $\xi \sim c/\omega$; (A5) continuum self-averaging over macroscopic test masses. Each is examined in turn. Honesty requires recording the failures as carefully as the success: an attack that only reports what survives is advocacy, not analysis.

2 Three Attacks That Fail (and Harden the No-Go)

2.1 Attack on A1: non-Gaussian statistics

Could rare, strong localization events (Poisson "hits," GRW-style) decohere efficiently while keeping force-noise *power* low? No. Decoherence at rate Γ with pointer resolution ξ is acquisition of which-path information at that rate, and the information–disturbance bound forces momentum transfer $\gtrsim \hbar/\xi$ per resolution event. The momentum diffusion $D_p \sim \hbar^2\Gamma/\xi^2$ is fixed by the second moment regardless of higher statistics, and accelerometers measure second moments. The no-go is statistics-independent.

2.2 Attack on A2: dephasing without forces

Could the channel dephase without exerting forces? Within T^{00} coupling, dephasing of a spatial superposition requires the field to differ between paths; spatial variation is a gradient; a gradient coupled to mass is a force. The limiting case—a spatially uniform fluctuating field—is exactly the case of a uniform fluctuating gravitational potential: by the equivalence principle it is pure gauge. It accelerates molecule and diffraction gratings identically and shifts no fringe, just as it deflects no accelerometer. The same symmetry that makes the channel universal makes its uniform component unobservable *to everyone equally.* Conclusion, sharpened: **for a universal mass coupling, molecular dephasing per baseline and differential accelerometry per baseline are the same observable measured at different baselines**—and the accelerometers' baselines are 10^6–10^{19} times longer. This is the deep reason the window calculation kept returning "closed."

2.3 Attack on A3: spectral reshaping and Doppler hiding

Could the channel's spectrum be band-limited to the 0.03–10 Hz gap between LISA Pathfinder/GRACE coverage and LIGO's band? Two independent failures. First, for a relativistic field (A4 still in force), $\omega \sim 1$ Hz implies $\xi \sim c/\omega \sim 10^8$ m: the long-correlation regime, where the $(\Delta x/\xi)^2$ suppression crushes the 100 nm molecular signal ten orders of magnitude harder than it hides the field from 10^5–10^7 m baselines (GRACE-FO, seismic networks). Computed maximum: $\sigma^2_{\mathrm{C}_{60}} \sim 10^{-13}$ against a detection requirement of 10^{-2}. Second, and more generally: any channel that produces momentum diffusion produces force noise that is *white down to DC*—a random walk has flat low-frequency spectral weight regardless of how fast the underlying kicks are. No Doppler shift, no resonance structure, no bandwidth engineering removes the DC tail that LISA Pathfinder reads. Attacks via A3 are closed generically.

3 The Attack That Partially Succeeds: A4

3.1 Breaking the frequency–correlation lock

A4 assumed field disturbances propagate at c. A *non-relativistic medium*—structure drifting at speed $v_m \ll c$—can combine sub-micron correlation length with low temporal frequency. The molecule then decoheres by *sweeping* through quasi-static spatial structure at its own beam velocity v_b: paths transversely separated by $\Delta x > \xi$ sample independent patches, each patch contributing phase $\theta \approx (Mc^2/\hbar)\,\varphi_{\mathrm{rms}}\,\xi/v_b$ at rate v_b/ξ, giving

$$\Gamma = \left(\frac{Mc^2}{\hbar}\right)^2 \varphi^2_{\mathrm{rms}}\,\frac{\xi}{v_b}\,. \qquad (1)$$

Mass-squared scaling survives; a new $1/v_b$ velocity dependence appears.

3.2 What still bites, and what is left

1. **LISA Pathfinder excludes the simple versions.** If the medium is at rest in any frame the spacecraft moves through (cosmic, solar, or Earth-centered), the test masses sweep it and the DC-white force noise of Sec. 2.3 applies; the computed acceleration noise at the atom-interferometry-saturated coupling exceeds the Pathfinder bound by $\sim 10^2$. Surviving versions must have the medium *comoving with each laboratory's free-fall frame*—a drag hypothesis with no mechanism, adopted here purely phenomenologically.

2. **Atom interferometry bounds the comoving version.** Slow atoms sweep the same medium at $v_b \sim 1$ m/s; by Eq. (1), slower probes are *more* sensitive per unit mass. Cesium fountain coherence ($\Gamma_{\mathrm{Cs}} \lesssim 0.1\ \mathrm{s}^{-1}$) caps the channel through the transfer law $\Gamma \propto M^2/v_b$:

Species	v_b	max Γ allowed	detection threshold ($\tau = 10$ ms)
C_{60} (720 amu)	150 m/s	0.02 s^{-1}	0.6 s^{-1} — **closed** (30×)
10^4 amu	150 m/s	3.8 s^{-1}	0.6 s^{-1} — **open** ($\sim 7\times$)
10^4 amu	50 m/s	11 s^{-1}	0.6 s^{-1} — **open** ($\sim 20\times$)

   The M^2 in the channel outruns the M^2 in the atomic bound only because heavy-molecule platforms probe masses no atom interferometer reaches: discovery space exists precisely where no lighter probe can pre-empt it.

3. **The cost ledger, in full.** The surviving corner requires: a preferred local frame (Lorentz violation); a medium dragged into co-motion with every laboratory's free-fall frame (unexplained); correlation length tuned to $\xi \lesssim$ the path separation; and intrinsic dynamics slow enough to evade BEC and trapped-atom bounds (motional-narrowing freedom in τ_c). Each evasion is a tuning. A referee should and will call this contrived, and this note does so first.

4 What the Surviving Corner Predicts

The corner's redeeming feature is that it cannot hide: Eq. (1) carries three signatures, each cheap to test on existing or near-term platforms.

1. **Mass-squared scaling**, as always—now testable only at $\gtrsim 10^3$ amu, repositioning the heavy-molecule program (LUMI-class, 10^4 amu targets) as the unique probe rather than one option among many.

2. **Inverse velocity dependence**: $\Gamma \propto 1/v_b$ at fixed species. LUMI's velocity selection makes this a nearly free differential test—slow beams should decohere *more* per unit time, opposite to most mundane backgrounds (collisional rates scale up with flux, blackbody with transit time in a way separable by design).

3. **Orientation anisotropy**: any residual lab-frame motion of the medium imprints a dependence of Γ on beam direction (and possibly sidereal time)—a smoking gun no conventional decoherence channel mimics.

5 Honest Conclusion

The no-go stands, harder than before, for every natural realization of the universal channel: relativistic, thermal, Gaussian or not, band-limited or not. The attack converts it from a calculation into three lemmas (information–disturbance, EP-gauge identity, DC-whiteness of random-walk noise) that future versions of ACT must respect. What survives is a single, multiply-tuned corner—a laboratory-comoving slow medium—whose entire viable signal space lies at $\gtrsim 10^3$ amu. For C_{60}, the original flagship experiment remains non-viable at 30× below threshold; that conclusion is unchanged and should be incorporated into the manuscripts. For 10^4 amu interferometry, one order of magnitude of contingent discovery space exists, carrying three falsifiable signatures. The PRL letter remains unsubmittable in its current form; a future letter, if any, belongs to the heavy-molecule corner with its anisotropy and velocity signatures stated as the discriminators—and with this note's cost ledger stated in the same breath.