



Opinion

Gravitational Signatures of Biological Information: A Proposed Testing Framework for the Mass-Energy-Information Equivalence Principle

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Abstract - The precise physical nature of information remains an open wound on the side of modern physics. While often treated as an abstract mathematical quantity, recent developments in the Mass-Energy-Information Equivalence Principle argue for a more material interpretation: that information carries finite mass. Parallel to this, the field of quantum biology has long wrestled with the possibility of macroscopic coherent states within living systems, most notably through the Orchestrated Objective Reduction hypothesis. This article offers a perspective that attempts to weld these two speculative frameworks into a single, testable prediction. We explore the speculative hypothesis that if biological systems indeed sustain macroscopic quantum coherence, their eventual decoherence must—according to information conservation principles—result in a physical mass defect. Unlike thermal dissipation, which is diffusive and slow, this “information crash” should theoretically release a sharp, gravitationally detectable transient. Here, we outline the constraints of such an event and propose a conceptual protocol using near-field atom interferometry to isolate this signal from the thermal background. The goal of this perspective is to move the debate on biological information from philosophy into the realm of falsifiable experimental physics.

Keywords - Information physics; Quantum biology; Mass-energy-information equivalence; Atom interferometry; Biological decoherence.

1 Introduction

Integrating information theory into the standard model of physics is no longer a fringe pursuit; it is a necessity. The proposal by Vopson [1] regarding the Mass-Energy-Information Equivalence Principle fundamentally shifts the definition of a “bit” from a semantic unit to a physical one, possessing a measurable mass defined by $m = E/c^2$. While the implications of this principle have been modeled in digital data storage and even cosmological dark matter, its biological consequences have been largely overlooked. This oversight is surprising, given that biological systems are arguably the most information-dense substrates in the known universe. In particular, the contentious but persistent field of quantum biology suggests that certain cellular structures—specifically microtubules—may operate as quantum information processors. The Orchestrated Objective Reduction (Orch-OR) theory [2] goes a step further, postulating that these structures can support coherent quantum states that

collapse in non-computable, synchronized events.

If we take both theories at face value, a contradiction appears in the standard thermodynamic view. A sudden massive collapse of a biological wavefunction is typically modeled only as heat loss. However, if information has mass, the erasure of such a complex state cannot only be thermal; it must also carry a gravitational signature. In this perspective, we explore the possibility of detecting this "information shockwave." This article is presented as a perspective to stimulate debate. We acknowledge that the proposal relies on the validity of two currently unverified hypotheses: the physical mass of information and the existence of macroscopic biological quantum states (Orch-OR).

2 Theoretical Framework

The argument rests on a strict application of Landauer's Principle. Conventionally, the erasure of one bit of information releases a minimum heat energy of $E = k_B T \cdot \ln(2)$. The Mass-Energy-Information Equivalence Principle extends this to imply a corresponding mass change:

$$\Delta m = \frac{k_B T \cdot \ln(2)}{c^2} \quad (1)$$

In a single-bit system, this mass is vanishingly small (10^{-40} Kg). However, biology does not operate on single bits. If a living system, such as a nematode or a localized neural cluster, maintains a coherent state involving entangled qubits in the order of $N \approx 10^{18}$ to 10^{27} the collective mass of this information becomes non-trivial. We posit a scenario where a biological system enters a "Fröhlich-style" condensate [3], effectively shielding its quantum state from the warm, wet environment. Upon the moment of decoherence, whether spontaneous or orchestrated, the system sheds this information mass. The critical distinction we make here is temporal: thermal relaxation is a diffusive process governed by phonons (heat), whereas the loss of information mass is an instantaneous subtraction from the local stress-energy tensor.

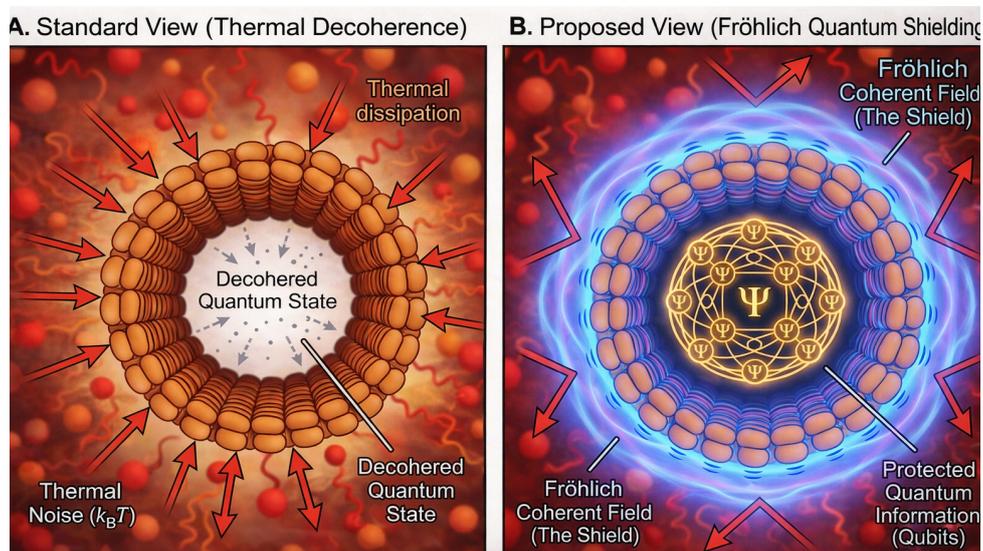


Figure 1: Schematic representation of the proposed mechanism. A biological system (microtubules, left) sustains a unitary information state shielded from thermal noise. Upon decoherence (right), the erasure of the information content results in a localized mass defect, distinct from the subsequent thermal radiation.

3 Proposed Experimental Approach

The challenge, naturally, is differentiating this gravitational transient from the overwhelming noise of biological metabolism and thermal jitter. We suggest that a Near-Field Cold Atom Interferometer could serve as the discriminator. The experimental concept involves placing a small biological sample (e.g., *C. elegans*) within a non-magnetic, vacuum-compatible housing. This assembly would be positioned in the near-field regime ($r < 3$ mm) of an atom cloud operating in gradiometer mode. The premise is that the $1/r$ gravitational potential change $\Delta\Phi$ is enhanced at these proximity scales:

$$\Delta\phi \approx \frac{G \cdot N \cdot \Delta m_{bit}}{r} \quad (2)$$

Standard gravimeters measure static mass or slow shifts. Our protocol would specifically look for high-frequency transients (< 10 ms) that correlate with the cessation of biological coherence (induced, for example, by rapid anesthesia or metabolic arrest).

4 Feasibility Estimates

Is this measurable? If we assume a coherence involving $N \approx 10^{27}$ qbits — an upper bound estimate for a macroscopic event—the resulting phase shift approaches 10^{-5} radian. These values should be treated as order-of-magnitude estimates intended to establish an experimental lower bound, rather than precise predictions of biological mass defects.

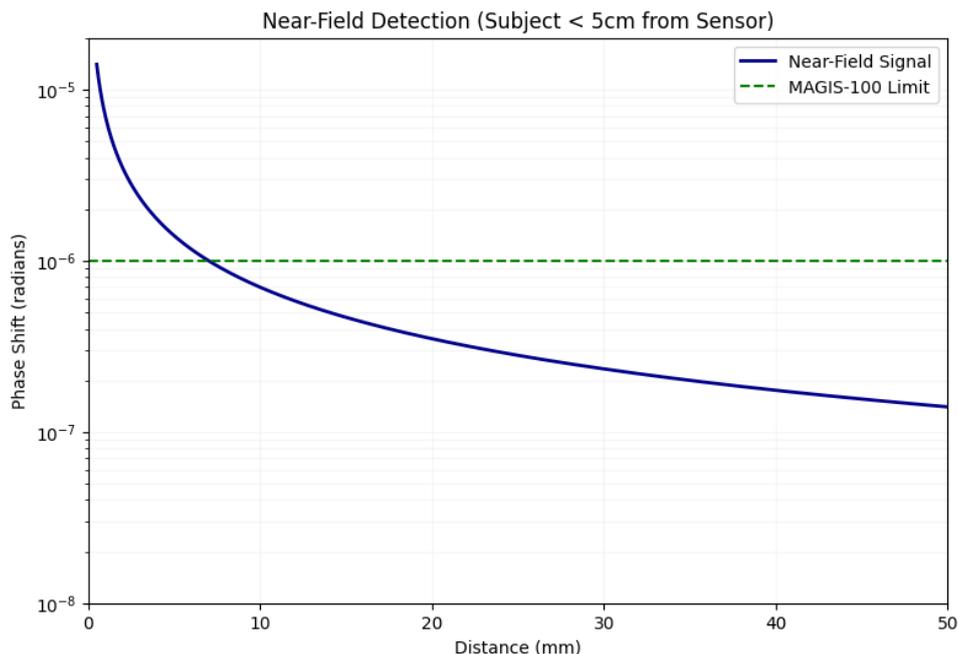


Figure 2: Projected signal strength (radians) as a function of radial distance (mm). The theoretical signal (solid line) is plotted against the noise floor of current MAGIS-class atom interferometers (dashed line). In the near-field regime ($r < 3$ mm), the signal amplitude theoretically exceeds the sensor’s detection threshold.

Current generation sensors, such as the MAGIS-100 [4], target sensitivities in the 10^{-6} radian range. While the mechanical noise of a living sample presents a formidable engineering hurdle, the signal magnitude is not, in principle, forbidden by the current limits of interferometry. This suggests that the experiment, while presenting significant technical challenges, faces engineering hurdles rather than fundamental physical prohibitions.

5 Conclusion

The convergence of Information Physics and Quantum Biology offers a radical new lens through which to view life. If the Mass-Energy-Information Equivalence Principle holds, then a biological entity is not just a collection of particles, but a reservoir of physical information mass. This opinion piece outlines a rudimentary road-map to test this. While highly speculative, the proposed search for a gravitational transient coincidence with biological decoherence provides a falsifiable prediction. We hope this perspective encourages experimentalists to look beyond the thermal noise and search for the gravitational weight of the biological state.

References

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