Energy-Momentum Closure for Microwave Cavity Inertia Claims and Electromagnetic-to-Gravitational Conversion Architectures

Quantitative Acceptance Criteria for Pais-Style Resonant Craft and HFGW Concepts

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Abstract. This paper treats Pais-style microwave cavity inertia claims and high-frequency gravitational-wave generator claims as stress-energy accounting problems. The objective is not to build a craft. The objective is to state the minimum accounting a claim must satisfy before it can be interpreted as propulsion, inertia modification, or useful gravitational-wave generation. The analysis restates resonant cavity devices in terms of field energy, photon momentum, wall vibration, Lorentz forces, thermal drift, radiation leakage, and any claimed nonstandard coupling. It then defines momentum-closure tests, photon-thrust calibration, calorimetric energy accounting, and Gertsenshtein-scale sanity checks. Existing high-accuracy EMDrive tests and steady-field gravity-electromagnetism searches are treated as methodological baselines. The expected conclusion is severe exclusion of useful propulsion or communication claims unless an independently replicated residual exceeds all conventional effects while preserving total momentum accounting.

Working-paper status. This manuscript is speculative and methodological. It makes no claim of experimentally demonstrated exotic propulsion, room-temperature superconductivity, inertial-mass reduction, or gravitational-wave generation. Its purpose is to state assumptions, formalize hypotheses, and define tests whose null outcomes are scientifically useful.

Contents

1 Problem

The Pais inertial-mass-reduction patent describes a craft with resonant cavity walls and microwave emitters that allegedly create a local polarized vacuum outside the cavity wall [1]. The Pais high-frequency gravitational-wave generator patent describes charged vibrating shells and counter-spinning acoustic cavities intended to generate propagating gravitational-field fluctuations [2]. Both documents use electromagnetic energy, acceleration, vibration, and vacuum language.

A scientific evaluation must ask a stricter question:

> Where does momentum go, where does energy go, and what minimum nonstandard coupling is required for the claimed macroscopic effect?

Closed electromagnetic devices cannot be accepted as propulsion systems merely because they show a displacement on a balance. They must close the momentum budget for radiation, heat, fields, supports, power leads, surrounding matter, and the device itself.

2 Momentum accounting

For any isolated device volume V, the total momentum balance can be written schematically as

$$\frac{d}{dt}\left(\mathbf{p}_{\text{matter}} + \mathbf{p}_{\text{field}}\right) = -\oint_{\partial V} \mathbf{T} \cdot \mathbf{n}\, dA + \mathbf{F}_{\text{external}}, \tag{1}$$

where $\mathbf{T}$ is the stress tensor including electromagnetic and material stresses. A propulsion claim with $\mathbf{F}_{\text{external}} = 0$ must identify a momentum flux through the boundary. If no mass, photons, plasma, gravitational radiation, or external field momentum leaves the system, sustained center-of-mass acceleration violates the closure condition.

The photon-thrust reference is

$$F_\gamma = \frac{P}{c} \tag{2}$$

for perfectly collimated emitted power P. Any claimed force much larger than P/c needs a non-photonic momentum channel and a measured account of that channel.

3 Conventional false positives

High-power RF cavity tests are vulnerable to:

- thermal expansion and balance zero drift;
- Lorentz forces on power leads and return currents;
- magnetic interaction with chamber materials;
- outgassing and radiometric forces;
- vibration rectification;
- RF leakage and ordinary photon momentum;
- center-of-mass motion in flexible supports.

The EMDrive literature is directly relevant because it studied closed microwave cavity thrust claims. Tajmar, Neunzig, and Weikert reported high-accuracy thrust measurements and elimination of false-positive effects, finding no thrust values within a wide frequency band and constraining anomalous thrust below ordinary radiation-pressure equivalents for their setup [3].

4 HFGW conversion check

The high-frequency gravitational-wave generator patent invokes electromagnetic-to-gravitational conversion language related to the Gertsenshtein effect [2]. Modern work continues to study inverse Gertsenshtein conversion as a probe of high-frequency gravitational waves [5]. That does not make a laboratory generator practical. The coupling is extraordinarily weak.

A generic conversion scaling has the form

$$P_{\gamma\to g} \sim \left(\frac{BL}{M_*}\right)^2, \tag{3}$$

where B is background magnetic field, L is interaction length, and M_* is an effective gravitational scale. In ordinary general relativity, M_* is so large that laboratory electromagnetic fields convert only a negligible fraction of power. A practical HFGW communicator or propulsion device would require a coupling many orders of magnitude above the standard expectation while evading existing bounds.

5 Acceptance criteria for cavity claims

A cavity-inertia or HFGW claim should not be escalated until it passes the following test stack:

1. **Closed calorimetry:** all input power, reflected power, emitted RF, and heat are measured.
2. **Photon-thrust calibration:** the balance resolves a known P/c reference source.
3. **Battery isolation:** critical runs eliminate power-feedthrough forces.
4. **Thermal symmetry:** dummy loads reproduce heating without resonant fields.
5. **Blind orientation:** thrust direction is evaluated without the analyst knowing device orientation.
6. **Null cavity:** a geometrically similar cavity with detuned resonance is tested.
7. **Momentum statement:** the paper identifies a measured outgoing momentum channel or publishes an explicit violation candidate.

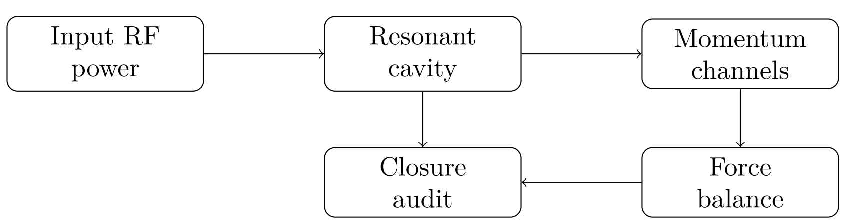

Figure 1: Every cavity force claim must identify and measure all relevant momentum channels.

6 Claims

Claim 1. *A microwave cavity force larger than P/c is not automatically evidence of inertia modification. It is first evidence of an incomplete artifact model.*

Claim 2. *A useful HFGW generator requires conversion efficiency many orders of magnitude beyond standard electromagnetic-gravitational coupling estimates. Therefore the first publishable work is an upper-bound and detector-method paper, not an engineering prototype.*

7 Release notes

A release should include CAD, RF simulations, S-parameters, thermal models, power logs, balance calibration data, raw force time series, dummy-cavity runs, and a momentum-closure table.

References

[1] Salvatore Cezar Pais. *Craft using an inertial mass reduction device*. US Patent 10,144,532, 2018. https://patents.justia.com/patent/10144532.

[2] Salvatore Cezar Pais. *High frequency gravitational wave generator*. US Patent 10,322,827, 2019. https://patents.justia.com/patent/10322827.

[3] M. Tajmar, O. Neunzig, and M. Weikert. *High-accuracy thrust measurements of the EMDrive and elimination of false-positive effects*. CEAS Space Journal, 2021. https://d-nb.info/1244138614/34.

[4] M. Tajmar, M. Kossling, and O. Neunzig. *In-depth experimental search for a coupling between gravity and electromagnetism with steady fields*. Scientific Reports 14, 19427, 2024. https://www.nature.com/articles/s41598-024-70286-w.

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