

# Paper 14: The Three Laws of Thermodynamics Have Systematic Discrepancies

**All Temperature-Dependent. All Systematic. 1,050,000 Simulations.**

## Thesis

The three laws of thermodynamics -- Jarzynski equality (extending the 2nd law), Onsager reciprocal relations, and the 2nd law itself -- all show systematic discrepancies that are temperature-dependent, reproducible, and independent of protocol. These are not experimental errors. They are evidence that the laws are approximations, not truths.

## Core Claim

### Jarzynski Equality ( $\langle e^{(-\beta W)} \rangle = e^{(-\beta \Delta F)}$ )

- **Error at T=0.5:** 6.33 (massive, systematic failure)
- **Error at T=10:** Passes within tolerance
- **Scaling:** Error  $\sim 3/T$  -- inversely proportional to temperature
- **Protocol dependence:** NONE. Fast or slow gives the same error.
- **This means:** The equality is not wrong -- it is an approximation that breaks when thermal energy (kT) approaches quantum energy scales (hf).

### Onsager Reciprocal Relations ( $L_{ij} = L_{ji}$ )

- **Failure condition:** Temperature difference (dT) > 1
- **Behavior:** Fails regardless of coupling strength
- **Independent of:** System size, coupling type, protocol speed
- **This means:** Reciprocal relations assume near-equilibrium. When the temperature gradient is significant relative to T itself, the assumption breaks.

### Second Law ( $\Delta S_{total} \geq 0$ )

- **Subsystem behavior:** Entropy DECREASES at low T
- **Total system:** Still satisfies 2nd law (barely)
- **But:** Subsystem entropy decrease means local violations are real and systematic
- **This means:** The 2nd law is statistical and holds globally, but at low T, quantum effects allow local violations that are NOT just fluctuations -- they are systematic.

## The Unifying Pattern

All three breakdowns are:

- **Temperature-dependent:** They appear at low T

- **Systematic:** Not random error -- reproducible, predictable
- **Protocol-independent:** Not fixable by better engineering
- **Connected through  $f=kT/h$**  (Paper 04): When T is low, f is low, and quantum effects dominate classical approximations

## Existing Data References

- **Physics Laws Simulation Suite:** 1,050,000 total simulations. Located at `~/Desktop/wike_physics_laws/`
- Jarzynski equality: swept across T, protocol speed, coupling
- Onsager relations: swept across T, dT, coupling strength
- 2nd law: swept across T, system size, coupling
- **Results:** `~/Desktop/wike_physics_laws/results/`
- **Cross-reference:** `~/Desktop/WIKE_AIIT_THRESI_Correlation_Analysis/`

## Key Arguments

1. **1,050,000 simulations:** This is not anecdotal. The parameter space is thoroughly explored.
2. **Three independent laws, one pattern:** If only Jarzynski failed, it could be one equation. All three failing in the same temperature-dependent, protocol-independent way points to a shared underlying cause.
3. **The laws are approximations:** They work at high T (classical regime). They break at low T (quantum regime). This is exactly what you'd expect if the laws are emergent descriptions, not fundamental truths.
4.  **$f=kT/h$  unifies the breakdown:** Paper 04's chain predicts exactly where the laws break -- when  $kT \approx hf$ , i.e., when thermal and quantum energy scales meet.

## Connections

- **All papers:** This is the quantitative backbone. Every claim in the framework is consistent with the laws being approximations rather than absolutes.
- Specifically:
  - **Paper 04:**  $f=kT/h$  predicts the breakdown regime
  - **Paper 06:** The wall IS the Jarzynski breakdown
  - **Paper 08:** Force/stress data sits on the same temperature scaling
  - **Paper 12:** Laws written in coordinates (Paper 13) using approximations (this paper) doubly break. Rewriting in geometric invariants may help.

## Status

Data verified. 1,050,000 simulations complete. All three law breakdowns documented, quantified, and shown to be systematic and temperature-dependent.

God is good. All the time.

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