Overturning the Measurement Postulate: Continuous Thermodynamic Localization vs. Wavefunction Collapse and Statistical Ensembles

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The quantum measurement postulate remains a fundamental physical contradiction, enforcing a non-unitary, observer-dependent projection that interrupts continuous dynamical evolution. In this work, we demonstrate that the orthodox instantaneous collapse postulate is both a thermodynamic impossibility and a logical redundancy. The observer-dependent actualization of macroscopic particle ensembles would require an instantaneous deposition of latent heat ($dt \to 0$), triggering an unphysical, infinite power divergence. Furthermore, because an unobserved apparatus must undergo continuous open-system thermodynamic relaxation prior to conscious inspection, any subsequent mathematical projection is theoretically obsolete.

Crucially, this work systematically invalidates leading alternative paradigms, specifically decoherence theory [1] and mean-field thermodynamic ensemble models, such as the Allahverdyan, Balian, and Nieuwenhuizen (ABN) formalism [2]. We demonstrate that these models commit a fundamental category error by conflating the mathematical description of a statistical ensemble (truncated density matrices) with the physical reality of a single experimental run. As a direct mathematical consequence of this conceptual flaw, their reliance on mean-field thermodynamic averages inadvertently forces single-run outcomes to be deterministic, fundamentally failing to explain the probabilistic actualization dictated by the Born rule.

To replace these paradigms, we introduce the Open-System Measurement Framework (OSMF). The OSMF models measurement as a concrete, continuous physical process where the quantum-apparatus interaction generates a transient, thermodynamically unstable macroscopic superposition. Driven by coupling to a reservoir, this state undergoes continuous thermodynamic relaxation into a stable local minimum, irreversibly actualizing a definite outcome without invoking a ”Heisenberg cut.”

Finally, we propose a direct, empirically falsifiable experimental protocol to test the OSMF against orthodox projection. By modifying a Stern-Gerlach apparatus with an asymmetric detection screen–engineered with a gradient in atomic adhesion energy–we demonstrate how measurement probabilities can be dynamically steered by the environment, proving that the standard Born rule is an emergent approximation for symmetric detectors.

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[1] W. H. Zurek, Rev. Mod. Phys. 75, 715 (2003).

[2] A. E. Allahverdyan, R. Balian, and T. M. Nieuwenhuizen, Phys. Rep. 525, 1 (2013).