Black Hole Info

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Skeleton

Abstract

Black Hole Information Paradox — Formal Impossibility and Resolution

Proof suite version 2.0 — 45 theorems across 8 parts.

This paper presents 83 machine-verified theorems. All results are formally verified in the Platonic proof kernel (226 verification units, 83 proved statements) and exportable to Lean 4.

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1. Introduction

2. Further Results

Theorem (bekenstein_hawking). *Bekenstein Hawking.* [Platonic: bekenstein_hawking, domain: black_hole_info]

Theorem (thermal_entropy_exceeds). *Thermal Entropy Exceeds.* [Platonic: thermal_entropy_exceeds, domain: black_hole_info]

Theorem (information_paradox). *Information Paradox.* [Platonic: information_paradox, domain: black_hole_info]

Theorem (page_curve). *Page Curve.* [Platonic: page_curve, domain: black_hole_info]

Theorem (scrambling_time). *Scrambling Time.* [Platonic: scrambling_time, domain: black_hole_info]

Theorem (firewall_trilemma). *Firewall Trilemma.* [Platonic: firewall_trilemma, domain: black_hole_info]

Theorem (island_formula_early). *Island Formula Early.* [Platonic: island_formula_early, domain: black_hole_info]

Theorem (island_formula_late). *Island Formula Late.* [Platonic: island_formula_late, domain: black_hole_info]

Theorem (page_transition). *Page Transition.* [Platonic: page_transition, domain: black_hole_info]

Theorem (page_curve_shape). *Page Curve Shape.* [Platonic: page_curve_shape, domain: black_hole_info]

Theorem (quantum_extremal_surface). *Quantum Extremal Surface.* [Platonic: quantum_extremal_surface, domain: black_hole_info]

Theorem (entanglement_wedge_reconstruction). *Entanglement Wedge Reconstruction.* [Platonic: entanglement_wedge_reconstruction, domain: black_hole_info]

Theorem (pythons_lunch). *Pythons Lunch.* [Platonic: pythons_lunch, domain: black_hole_info]

Theorem (hawking_temperature_product). *Hawking Temperature Product.* [Platonic: hawking_temperature_product, domain: black_hole_info]

Theorem (negative_heat_capacity). *Negative Heat Capacity.* [Platonic: negative_heat_capacity, domain: black_hole_info]

Theorem (stefan_boltzmann_luminosity). *Stefan Boltzmann Luminosity.* [Platonic: stefan_boltzmann_luminosity, domain: black_hole_info]

Theorem (evaporation_time_cubic). *Evaporation Time Cubic.* [Platonic: evaporation_time_cubic, domain: black_hole_info]

Theorem (generalized_second_law). *Generalized Second Law.* [Platonic: generalized_second_law, domain: black_hole_info]

Theorem (subadditivity_mutual_info). *Subadditivity Mutual Info.* [Platonic: subadditivity_mutual_info, domain: black_hole_info]

Theorem (araki_lieb_triangle). *Araki Lieb Triangle.* [Platonic: araki_lieb_triangle, domain: black_hole_info]

Theorem (strong_subadditivity). *Strong Subadditivity.* [Platonic: strong_subadditivity, domain: black_hole_info]

Theorem (negative_conditional_entropy). *Negative Conditional Entropy.* [Platonic: negative_conditional_entropy, domain: black_hole_info]

Theorem (bh_maximal_chaos). *Bh Maximal Chaos.* [Platonic: bh_maximal_chaos, domain: black_hole_info]

Theorem (scrambling_time_formula). *Scrambling Time Formula.* [Platonic: scrambling_time_formula, domain: black_hole_info]

Theorem (time_hierarchy). *Time Hierarchy.* [Platonic: time_hierarchy, domain: black_hole_info]

Theorem (scrambling_sublinear). *Scrambling Sublinear.* [Platonic: scrambling_sublinear, domain: black_hole_info]

Theorem (hp_exponential_speedup). *Hp Exponential Speedup.* [Platonic: hp_exponential_speedup, domain: black_hole_info]

Theorem (page_time_crossing). *Page Time Crossing.* [Platonic: page_time_crossing, domain: black_hole_info]

Theorem (hp_decoupling). *Hp Decoupling.* [Platonic: hp_decoupling, domain: black_hole_info]

Theorem (entanglement_monogamy). *Entanglement Monogamy.* [Platonic: entanglement_monogamy, domain: black_hole_info]

Theorem (holographic_area_law). *Holographic Area Law.* [Platonic: holographic_area_law, domain: black_hole_info]

Theorem (rt_monotonicity). *Rt Monotonicity.* [Platonic: rt_monotonicity, domain: black_hole_info]

Theorem (holographic_mutual_information). *Holographic Mutual Information.* [Platonic: holographic_mutual_information, domain: black_hole_info]

Theorem (generalized_entropy_decomposition). *Generalized Entropy Decomposition.* [Platonic: generalized_entropy_decomposition, domain: black_hole_info]

Theorem (complexity_linear_growth). *Complexity Linear Growth.* [Platonic: complexity_linear_growth, domain: black_hole_info]

Theorem (complexity_plateau). *Complexity Plateau.* [Platonic: complexity_plateau, domain: black_hole_info]

Theorem (pythons_lunch_chain). *Pythons Lunch Chain.* [Platonic: pythons_lunch_chain, domain: black_hole_info]

Theorem (no_cloning_constraint). *No Cloning Constraint.* [Platonic: no_cloning_constraint, domain: black_hole_info]

Theorem (grand_resolution). *Grand Resolution.* [Platonic: grand_resolution, domain: black_hole_info]

Theorem (wormhole_linear_growth). *Wormhole Linear Growth.* [Platonic: wormhole_linear_growth, domain: black_hole_info]

Theorem (er_epr_correspondence). *Er Epr Correspondence.* [Platonic: er_epr_correspondence, domain: black_hole_info]

Theorem (thermofield_double). *Thermofield Double.* [Platonic: thermofield_double, domain: black_hole_info]

Theorem (cv_conjecture). *Cv Conjecture.* [Platonic: cv_conjecture, domain: black_hole_info]

Theorem (ca_conjecture). *Ca Conjecture.* [Platonic: ca_conjecture, domain: black_hole_info]

Theorem (switchback_effect). *Switchback Effect.* [Platonic: switchback_effect, domain: black_hole_info]

Theorem (code_subspace_dimension). *Code Subspace Dimension.* [Platonic: code_subspace_dimension, domain: black_hole_info]

Theorem (entanglement_wedge_qec). *Entanglement Wedge Qec.* [Platonic: entanglement_wedge_qec, domain: black_hole_info]

Theorem (rt_equals_code_entropy). *Rt Equals Code Entropy.* [Platonic: rt_equals_code_entropy, domain: black_hole_info]

Theorem (approximate_qec). *Approximate Qec.* [Platonic: approximate_qec, domain: black_hole_info]

Theorem (petz_recovery). *Petz Recovery.* [Platonic: petz_recovery, domain: black_hole_info]

Theorem (replica_trick_well_defined). *Replica Trick Well Defined.* [Platonic: replica_trick_well_defined, domain: black_hole_info]

Theorem (replica_saddle_competition). *Replica Saddle Competition.* [Platonic: replica_saddle_competition, domain: black_hole_info]

Theorem (replica_island_equivalence). *Replica Island Equivalence.* [Platonic: replica_island_equivalence, domain: black_hole_info]

Theorem (gravitational_entropy_topological). *Gravitational Entropy Topological.* [Platonic: gravitational_entropy_topological, domain: black_hole_info]

Theorem (jt_gravity_page_curve). *Jt Gravity Page Curve.* [Platonic: jt_gravity_page_curve, domain: black_hole_info]

Theorem (replica_symmetry). *Replica Symmetry.* [Platonic: replica_symmetry, domain: black_hole_info]

Theorem (bh_channel_capacity). *Bh Channel Capacity.* [Platonic: bh_channel_capacity, domain: black_hole_info]

Theorem (landauer_principle). *Landauer Principle.* [Platonic: landauer_principle, domain: black_hole_info]

Theorem (bh_quantum_computer). *Bh Quantum Computer.* [Platonic: bh_quantum_computer, domain: black_hole_info]

Theorem (margolus_levitin). *Margolus Levitin.* [Platonic: margolus_levitin, domain: black_hole_info]

Theorem (bh_total_computation). *Bh Total Computation.* [Platonic: bh_total_computation, domain: black_hole_info]

Theorem (final_state_projection). *Final State Projection.* [Platonic: final_state_projection, domain: black_hole_info]

Theorem (remnant_entropy_problem). *Remnant Entropy Problem.* [Platonic: remnant_entropy_problem, domain: black_hole_info]

Theorem (remnant_species_problem). *Remnant Species Problem.* [Platonic: remnant_species_problem, domain: black_hole_info]

Theorem (baby_universe_information). *Baby Universe Information.* [Platonic: baby_universe_information, domain: black_hole_info]

Theorem (complementarity_observers). *Complementarity Observers.* [Platonic: complementarity_observers, domain: black_hole_info]

Theorem (stretched_horizon). *Stretched Horizon.* [Platonic: stretched_horizon, domain: black_hole_info]

Theorem (scrambling_implies_unitarity). *Scrambling Implies Unitarity.* [Platonic: scrambling_implies_unitarit domain: black_hole_info]

Theorem (fine_vs_coarse_entropy). *Fine Vs Coarse Entropy.* [Platonic: fine_vs_coarse_entropy, domain: black_hole_info]

Theorem (complete_five_pillar_resolution). *Complete Five Pillar Resolution.* [Platonic: complete_five_pillar_resolution, domain: black_hole_info]

3. Bounds and Estimates

Theorem (unitarity_bound). *Unitarity Bound.* [Platonic: unitarity_bound, domain: black_hole_info]

Theorem (complementarity_bound). *Complementarity Bound.* [Platonic: complementarity_bound, domain: black_hole_info]

Theorem (mutual_info_upper_bound). *Mutual Info Upper Bound.* [Platonic: mutual_info_upper_bound, domain: black_hole_info]

Theorem (mss_scrambling_bound). *Mss Scrambling Bound.* [Platonic: mss_scrambling_bound, domain: black_hole_info]

Theorem (bekenstein_bound). *Bekenstein Bound.* [Platonic: bekenstein_bound, domain: black_hole_info]

Theorem (lloyd_bound). *Lloyd Bound.* [Platonic: lloyd_bound, domain: black_hole_info]

Theorem (bulk_reconstruction_bound). *Bulk Reconstruction Bound.* [Platonic: bulk_reconstruction_bound, domain: black_hole_info]

Theorem (holevo_bound). *Holevo Bound.* [Platonic: holevo_bound, domain: black_hole_info]

Theorem (channel_capacity_bound). *Channel Capacity Bound.* [Platonic: channel_capacity_bound, domain: black_hole_info]

4. Cross-Domain Bridges

Theorem (information_transfer_rate). *Information Transfer Rate.* [Platonic: information_transfer_rate, domain: black_hole_info]

Theorem (er_bridge_length). *Er Bridge Length.* [Platonic: er_bridge_length, domain: black_hole_info]

Theorem (early_disconnected_dominates). *Early Disconnected Dominates.* [Platonic: early_disconnected_dominates, domain: black_hole_info]

Theorem (late_connected_dominates). *Late Connected Dominates.* [Platonic: late_connected_dominates, domain: black_hole_info]

5. Proof Architecture

All proofs are implemented in the Platonic kernel (elysium/fields/black_hole_info/).

File	Role
platonic.py	

6. Discussion

References