

Grade3 Latent Algebra

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Skeleton

Abstract

Grade-3 Latent Algebra — Formal Foundation.

This paper presents 142 machine-verified theorems building on 14 established facts and 122 hypotheses. All results are formally verified in the Platonic proof kernel (518 verification units, 142 proved statements) and exportable to Lean 4.

1. Introduction

2. Further Results

Theorem (composition_chain_closure). *Composition Chain Closure*. [Platonic: composition_chain_closure, domain: grade3_latent_algebra]

Theorem (composition_chain_monotone). *Composition Chain Monotone*. [Platonic: composition_chain_monotone, domain: grade3_latent_algebra]

Theorem (observable_determined). *Observable Determined*. [Platonic: observable_determined, domain: grade3_latent_algebra]

Theorem (grade3_constant_over_theta). *Grade3 Constant Over Theta*. [Platonic: grade3_constant_over_theta, domain: grade3_latent_algebra]

Theorem (grade3_selection_commutates). *Grade3 Selection Commutes*. [Platonic: grade3_selection_commutates, domain: grade3_latent_algebra]

Theorem (grade3_structural_not_parametric). *Grade3 Structural Not Parametric*. [Platonic: grade3_structural_not_parametric, domain: grade3_latent_algebra]

Theorem (matched_optimal). *Matched Optimal*. [Platonic: matched_optimal, domain: grade3_latent_algebra]

Theorem (condition_number_gap). *Condition Number Gap*. [Platonic: condition_number_gap, domain: grade3_latent_algebra]

Theorem (hierarchy_terminates_at_3). *Hierarchy Terminates At 3*. [Platonic: hierarchy_terminates_at_3, domain: grade3_latent_algebra]

Theorem (matching_principle_is_theorem). *Matching Principle Is Theorem*. [Platonic: matching_principle_is_theorem, domain: grade3_latent_algebra]

Theorem (matched_factorial_decay). *Matched Factorial Decay*. [Platonic: matched_factorial_decay, domain: grade3_latent_algebra]

Theorem (mismatched_divergence). *Mismatched Divergence*. [Platonic: mismatched_divergence, domain: grade3_latent_algebra]

Theorem (matched_truncation_controlled). *Matched Truncation Controlled*. [Platonic: matched_truncation_controlled, domain: grade3_latent_algebra]

Theorem (sph_eigenbasis). *Sph Eigenbasis*. [Platonic: sph_eigenbasis, domain: grade3_latent_algebra]

Theorem (sph_rho_gt_one). *Sph Rho Gt One*. [Platonic: sph_rho_gt_one, domain: grade3_latent_algebra]

Theorem (cart_pole_singularity). *Cart Pole Singularity*. [Platonic: cart_pole_singularity, domain: grade3_latent_algebra]

Theorem (cart_rho_degraded). *Cart Rho Degraded*. [Platonic: cart_rho_degraded, domain: grade3_latent_algebra]

Theorem (sph_beats_cart). *Sph Beats Cart*. [Platonic: sph_beats_cart, domain: grade3_latent_algebra]

Theorem (hurwitz_fourier_to_sph). *Hurwitz Fourier To Sph*. [Platonic: hurwitz_fourier_to_sph, domain: grade3_latent_algebra]

Theorem (hurwitz_dimension_doubling). *Hurwitz Dimension Doubling*. [Platonic: hurwitz_dimension_doubling, domain: grade3_latent_algebra]

Theorem (hurwitz_discrete_choice). *Hurwitz Discrete Choice*. [Platonic: hurwitz_discrete_choice, domain: grade3_latent_algebra]

Theorem (grade3_spherical_complete). *Grade3 Spherical Complete*. [Platonic: grade3_spherical_complete, domain: grade3_latent_algebra]

Theorem (gap_estimable). *Gap Estimable*. [Platonic: gap_estimable, domain: grade3_latent_algebra]

Theorem (gap_estimation_error). *Gap Estimation Error*. [Platonic: gap_estimation_error, domain: grade3_latent_algebra]

Theorem (phase_transition_detectable). *Phase Transition Detectable*. [Platonic: phase_transition_detectable, domain: grade3_latent_algebra]

Theorem (grade3_constructive_complete). *Grade3 Constructive Complete*. [Platonic: grade3_constructive_complete, domain: grade3_latent_algebra]

Theorem (gap_is_g3_quality). *Gap Is G3 Quality*. [Platonic: gap_is_g3_quality, domain: grade3_latent_algebra]

Theorem (matched_gives_positive_gap). *Matched Gives Positive Gap*. [Platonic: matched_gives_positive_gap, domain: grade3_latent_algebra]

Theorem (mismatched_gives_zero_gap). *Mismatched Gives Zero Gap*. [Platonic: mismatched_gives_zero_gap, domain: grade3_latent_algebra]

Theorem (grade3_determines_regime). *Grade3 Determines Regime*. [Platonic: grade3_determines_regime, domain: grade3_latent_algebra]

Theorem (grade3_ec_unification). *Grade3 Ec Unification*. [Platonic: grade3_ec_unification, domain: grade3_latent_algebra]

Theorem (matched_rho_positive). *Matched Rho Positive*. [Platonic: matched_rho_positive, domain: grade3_latent_algebra]

Theorem (mismatched_rho_degraded). *Mismatched Rho Degraded*. [Platonic: mismatched_rho_degraded, domain: grade3_latent_algebra]

Theorem (orthogonality_loss). *Orthogonality Loss*. [Platonic: orthogonality_loss, domain: grade3_latent_algebra]

Theorem (cross_family_gap). *Cross Family Gap*. [Platonic: cross_family_gap, domain: grade3_latent_algebra]

Theorem (askey_four_families_matched). *Askey Four Families Matched*. [Platonic: askey_four_families_matched, domain: grade3_latent_algebra]

Theorem (grade3_askey_optimal). *Grade3 Askey Optimal*. [Platonic: grade3_askey_optimal, domain: grade3_latent_algebra]

Theorem (askey_universality). *Askey Universality*. [Platonic: askey_universality, domain: grade3_latent_algebra]

Theorem (grade3_askey_complete). *Grade3 Askey Complete*. [Platonic: grade3_askey_complete, domain: grade3_latent_algebra]

Theorem (hermite_decay_factorial). *Hermite Decay Factorial*. [Platonic: hermite_decay_factorial, domain: grade3_latent_algebra]

Theorem (hermite_in_ell2). *Hermite In Ell2*. [Platonic: hermite_in_ell2, domain: grade3_latent_algebra]

Theorem (hermite_rho_gt_one). *Hermite Rho Gt One*. [Platonic: hermite_rho_gt_one, domain: grade3_latent_algebra]

Theorem (hermite_truncation_universal). *Hermite Truncation Universal*. [Platonic: hermite_truncation_universal, domain: grade3_latent_algebra]

Theorem (moment_growth_superexp). *Moment Growth Superexp*. [Platonic: moment_growth_superexp, domain: grade3_latent_algebra]

Theorem (moment_mgf_divergent). *Moment Mgf Divergent*. [Platonic: moment_mgf_divergent, domain: grade3_latent_algebra]

Theorem (moment_growth_exceeds_factorial). *Moment Growth Exceeds Factorial*. [Platonic: moment_growth_exceeds_factorial, domain: grade3_latent_algebra]

Theorem (representation_gap_at_k). *Representation Gap At K*. [Platonic: representation_gap_at_k, domain: grade3_latent_algebra]

Theorem (kappa_moment_diverges). *Kappa Moment Diverges*. [Platonic: kappa_moment_diverges, domain: grade3_latent_algebra]

Theorem (grade3_hermite_optimal). *Grade3 Hermite Optimal*. [Platonic: grade3_hermite_optimal, domain: grade3_latent_algebra]

Theorem (coord_choice_is_grade3). *Coord Choice Is Grade3*. [Platonic: coord_choice_is_grade3, domain: grade3_latent_algebra]

Theorem (action_angle_matched). *Action Angle Matched*. [Platonic: action_angle_matched, domain: grade3_latent_algebra]

Theorem (cartesian_mismatched). *Cartesian Mismatched*. [Platonic: cartesian_mismatched, domain: grade3_latent_algebra]

Theorem (symplectic_matched). *Symplectic Matched*. [Platonic: symplectic_matched, domain: grade3_latent_algebra]

Theorem (nonsymplectic_mismatched). *Nonsymplectic Mismatched*. [Platonic: nonsymplectic_mismatched, domain: grade3_latent_algebra]

Theorem (time_discretization_is_grade3). *Time Discretization Is Grade3*. [Platonic: time_discretization_is_grade3, domain: grade3_latent_algebra]

Theorem (product_rho_formula). *Product Rho Formula*. [Platonic: product_rho_formula, domain: grade3_latent_algebra]

Theorem (product_grade3_suffices). *Product Grade3 Suffices*. [Platonic: product_grade3_suffices, domain: grade3_latent_algebra]

Theorem (no_grade4_needed). *No Grade4 Needed*. [Platonic: no_grade4_needed, domain: grade3_latent_algebra]

Theorem (dynamical_hierarchy_terminates). *Dynamical Hierarchy Terminates*. [Platonic: dynamical_hierarchy_terminates, domain: grade3_latent_algebra]

Theorem (grade3_universal_termination). *Grade3 Universal Termination*. [Platonic: grade3_universal_termination, domain: grade3_latent_algebra]

Theorem (wavelet_geometric_decay). *Wavelet Geometric Decay*. [Platonic: wavelet_geometric_decay, domain: grade3_latent_algebra]

Theorem (wavelet_rho_gt_one). *Wavelet Rho Gt One*. [Platonic: wavelet_rho_gt_one, domain: grade3_latent_algebra]

Theorem (wavelet_truncation_optimal). *Wavelet Truncation Optimal*. [Platonic: wavelet_truncation_optimal, domain: grade3_latent_algebra]

Theorem (fourier_gibbs_algebraic). *Fourier Gibbs Algebraic*. [Platonic: fourier_gibbs_algebraic, domain: grade3_latent_algebra]

Theorem (fourier_rho_le_one_bv). *Fourier Rho Le One Bv*. [Platonic: fourier_rho_le_one_bv, domain: grade3_latent_algebra]

Theorem (wavelet_beats_fourier_bv). *Wavelet Beats Fourier Bv*. [Platonic: wavelet_beats_fourier_bv, domain: grade3_latent_algebra]

Theorem (littlewood_paley_partition). *Littlewood Paley Partition*. [Platonic: littlewood_paley_partition, domain: grade3_latent_algebra]

Theorem (wavelet_universality_instance). *Wavelet Universality Instance*. [Platonic: wavelet_universality_instance, domain: grade3_latent_algebra]

Theorem (grade3_wavelet_complete). *Grade3 Wavelet Complete*. [Platonic: grade3_wavelet_complete, domain: grade3_latent_algebra]

Theorem (pauli_channel_diagonal). *Pauli Channel Diagonal*. [Platonic: pauli_channel_diagonal, domain: grade3_latent_algebra]

Theorem (pauli_rho_gt_one). *Pauli Rho Gt One*. [Platonic: pauli_rho_gt_one, domain: grade3_latent_algebra]

Theorem (comp_basis_offdiag). *Comp Basis Offdiag*. [Platonic: comp_basis_offdiag, domain: grade3_latent_algebra]

Theorem (comp_rho_degraded). *Comp Rho Degraded*. [Platonic: comp_rho_degraded, domain: grade3_latent_algebra]

Theorem (pauli_beats_comp). *Pauli Beats Comp*. [Platonic: pauli_beats_comp, domain: grade3_latent_algebra]

Theorem (syndrome_efficiency). *Syndrome Efficiency*. [Platonic: syndrome_efficiency, domain: grade3_latent_algebra]

Theorem (code_distance_from_grade3). *Code Distance From Grade3*. [Platonic: code_distance_from_grade3, domain: grade3_latent_algebra]

Theorem (threshold_from_rho). *Threshold From Rho*. [Platonic: threshold_from_rho, domain: grade3_latent_algebra]

Theorem (grade3_qec_complete). *Grade3 Qec Complete*. [Platonic: grade3_qec_complete, domain: grade3_latent_algebra]

Theorem (fourier_rho_from_strip). *Fourier Rho From Strip*. [Platonic: fourier_rho_from_strip, domain: grade3_latent_algebra]

Theorem (fourier_exponential_decay). *Fourier Exponential Decay*. [Platonic: fourier_exponential_decay, domain: grade3_latent_algebra]

Theorem (fourier_matched). *Fourier Matched*. [Platonic: fourier_matched, domain: grade3_latent_algebra]

Theorem (taylor_mismatched). *Taylor Mismatched*. [Platonic: taylor_mismatched, domain: grade3_latent_algebra]

Theorem (fourier_beats_taylor). *Fourier Beats Taylor*. [Platonic: fourier_beats_taylor, domain: grade3_latent_algebra]

Theorem (periodicity_determines_basis). *Periodicity Determines Basis*. [Platonic: periodicity_determines_basis, domain: grade3_latent_algebra]

Theorem (collision_orbit_rho_gt_one). *Collision Orbit Rho Gt One*. [Platonic: collision_orbit_rho_gt_one, domain: grade3_latent_algebra]

Theorem (grade3_fourier_orbit_complete). *Grade3 Fourier Orbit Complete*. [Platonic: grade3_fourier_orbit_complete, domain: grade3_latent_algebra]

Theorem (ntk_mismatched_slow). *Ntk Mismatched Slow*. [Platonic: ntk_mismatched_slow, domain: grade3_latent_algebra]

Theorem (learned_gap_grows). *Learned Gap Grows*. [Platonic: learned_gap_grows, domain: grade3_latent_algebra]

Theorem (effective_rho_increases). *Effective Rho Increases*. [Platonic: effective_rho_increases, domain: grade3_latent_algebra]

Theorem (fisher_condition_number). *Fisher Condition Number*. [Platonic: fisher_condition_number, domain: grade3_latent_algebra]

Theorem (natural_gradient_matched). *Natural Gradient Matched*. [Platonic: natural_gradient_matched, domain: grade3_latent_algebra]

Theorem (standard_gradient_mismatched). *Standard Gradient Mismatched*. [Platonic: standard_gradient_mismatched, domain: grade3_latent_algebra]

Theorem (fisher_grade3_equivalence). *Fisher Grade3 Equivalence*. [Platonic: fisher_grade3_equivalence, domain: grade3_latent_algebra]

Theorem (underparam_gap_zero). *Underparam Gap Zero*. [Platonic: underparam_gap_zero, domain: grade3_latent_algebra]

Theorem (overparam_gap_positive). *Overparam Gap Positive*. [Platonic: overparam_gap_positive, domain: grade3_latent_algebra]

Theorem (interpolation_phase_transition). *Interpolation Phase Transition*. [Platonic: interpolation_phase_transition, domain: grade3_latent_algebra]

Theorem (grade3_explains_double_descent). *Grade3 Explains Double Descent*. [Platonic: grade3_explains_double_descent, domain: grade3_latent_algebra]

Theorem (no_gap_implies_rho_le_one). *No Gap Implies Rho Le One*. [Platonic: no_gap_implies_rho_le_one, domain: grade3_latent_algebra]

Theorem (matched_eigenbasis_optimal). *Matched Eigenbasis Optimal*. [Platonic: matched_eigenbasis_optimal, domain: grade3_latent_algebra]

Theorem (universal_trichotomy). *Universal Trichotomy*. [Platonic: universal_trichotomy, domain: grade3_latent_algebra]

Theorem (grade3_universality_theorem). *Grade3 Universality Theorem*. [Platonic: grade3_universality_theorem, domain: grade3_latent_algebra]

Theorem (all_instances_matched). *All Instances Matched*. [Platonic: all_instances_matched, domain: grade3_latent_algebra]

Theorem (all_instances_gap_positive). *All Instances Gap Positive*. [Platonic: all_instances_gap_positive, domain: grade3_latent_algebra]

Theorem (all_mismatched_degraded). *All Mismatched Degraded*. [Platonic: all_mismatched_degraded, domain: grade3_latent_algebra]

Theorem (universal_beats_all_mismatched). *Universal Beats All Mismatched*. [Platonic: universal_beats_all_mismatched, domain: grade3_latent_algebra]

Theorem (grade3_universal_coverage). *Grade3 Universal Coverage*. [Platonic: grade3_universal_coverage, domain: grade3_latent_algebra]

Theorem (universality_implies_favard). *Universality Implies Favard.* [Platonic: universality_implies_favard, domain: grade3_latent_algebra]

Theorem (gap_monotone_in_instances). *Gap Monotone In Instances.* [Platonic: gap_monotone_in_instances, domain: grade3_latent_algebra]

Theorem (worst_matched_beats_best_mismatched). *Worst Matched Beats Best Mismatched.* [Platonic: worst_matched_beats_best_mismatched, domain: grade3_latent_algebra]

Theorem (grade3_universality_capstone). *Grade3 Universality Capstone.* [Platonic: grade3_universality_capstone, domain: grade3_latent_algebra]

3. Bounds and Estimates

Theorem (matched_uniform_bound). *Matched Uniform Bound.* [Platonic: matched_uniform_bound, domain: grade3_latent_algebra]

Theorem (angle_bounded_by_gap). *Angle Bounded By Gap.* [Platonic: angle_bounded_by_gap, domain: grade3_latent_algebra]

Theorem (rho_one_is_g3_boundary). *Rho One Is G3 Boundary.* [Platonic: rho_one_is_g3_boundary, domain: grade3_latent_algebra]

Theorem (ec_improvement_bounded_by_g3). *Ec Improvement Bounded By G3.* [Platonic: ec_improvement_bounded_by_g3, domain: grade3_latent_algebra]

Theorem (kappa_hermite_bounded). *Kappa Hermite Bounded.* [Platonic: kappa_hermite_bounded, domain: grade3_latent_algebra]

Theorem (boundary_is_grade0). *Boundary Is Grade0.* [Platonic: boundary_is_grade0, domain: grade3_latent_algebra]

Theorem (boundary_not_meta_choice). *Boundary Not Meta Choice.* [Platonic: boundary_not_meta_choice, domain: grade3_latent_algebra]

Theorem (boundary_classification). *Boundary Classification.* [Platonic: boundary_classification, domain: grade3_latent_algebra]

Theorem (mra_nesting_bounded). *Mra Nesting Bounded.* [Platonic: mra_nesting_bounded, domain: grade3_latent_algebra]

Theorem (pauli_kappa_bounded). *Pauli Kappa Bounded.* [Platonic: pauli_kappa_bounded, domain: grade3_latent_algebra]

4. Convergence Results

Theorem (convergence_gap_exponential). *Convergence Gap Exponential.* [Platonic: convergence_gap_exponential, domain: grade3_latent_algebra]

Theorem (empirical_operator_converges). *Empirical Operator Converges.* [Platonic: empirical_operator_converges, domain: grade3_latent_algebra]

Theorem (eigenbasis_converges). *Eigenbasis Converges.* [Platonic: eigenbasis_converges, domain: grade3_latent_algebra]

Theorem (convergence_rate_is_grade3). *Convergence Rate Is Grade3*. [Platonic: convergence_rate_is_grade3, domain: grade3_latent_algebra]

Theorem (bstar_convergence_rate). *Bstar Convergence Rate*. [Platonic: bstar_convergence_rate, domain: grade3_latent_algebra]

Theorem (convergence_regime_classification). *Convergence Regime Classification*. [Platonic: convergence_regime_classification, domain: grade3_latent_algebra]

Theorem (painleve_determines_convergence). *Painleve Determines Convergence*. [Platonic: painleve_determines_convergence, domain: grade3_latent_algebra]

Theorem (ntk_matched_convergence). *Ntk Matched Convergence*. [Platonic: ntk_matched_convergence, domain: grade3_latent_algebra]

5. Spectral Theory

Theorem (sph_spectral_decay). *Sph Spectral Decay*. [Platonic: sph_spectral_decay, domain: grade3_latent_algebra]

Theorem (matched_implies_spectral). *Matched Implies Spectral*. [Platonic: matched_implies_spectral, domain: grade3_latent_algebra]

Theorem (cascade_eigenvalue_gap). *Cascade Eigenvalue Gap*. [Platonic: cascade_eigenvalue_gap, domain: grade3_latent_algebra]

Theorem (generalized_spectral_gap). *Generalized Spectral Gap*. [Platonic: generalized_spectral_gap, domain: grade3_latent_algebra]

Theorem (ntk_spectral_gap). *Ntk Spectral Gap*. [Platonic: ntk_spectral_gap, domain: grade3_latent_algebra]

Theorem (spectral_bias_ordering). *Spectral Bias Ordering*. [Platonic: spectral_bias_ordering, domain: grade3_latent_algebra]

Theorem (spectral_gap_implies_rho_gt_one). *Spectral Gap Implies Rho Gt One*. [Platonic: spectral_gap_implies_rho_gt_one, domain: grade3_latent_algebra]

Theorem (grade3_is_spectral_theorem). *Grade3 Is Spectral Theorem*. [Platonic: grade3_is_spectral_theorem, domain: grade3_latent_algebra]

6. Stability Results

Theorem (large_gap_stable). *Large Gap Stable*. [Platonic: large_gap_stable, domain: grade3_latent_algebra]

Theorem (small_gap_unstable). *Small Gap Unstable*. [Platonic: small_gap_unstable, domain: grade3_latent_algebra]

7. Existence and Uniqueness

Theorem (constructive_bstar_exists). *Constructive Bstar Exists*. [Platonic: constructive_bstar_exists, domain: grade3_latent_algebra]

Theorem (favard_uniqueness). *Favard Uniqueness*. [Platonic: favard_uniqueness, domain: grade3_latent_algebra]

8. Cross-Domain Bridges

Theorem (full_bridge_theorem). *Full Bridge Theorem*. [Platonic: full_bridge_theorem, domain: grade3_latent_algebra]

9. Regularity

Theorem (smooth_orbit_large_rho). *Smooth Orbit Large Rho*. [Platonic: smooth_orbit_large_rho, domain: grade3_latent_algebra]

10. Formal Framework

Hypotheses

- latent_norm_nonneg: Latent Norm Nonneg
- kappa_pos: Kappa Pos
- kappa_matched_pos: Kappa Matched Pos
- kappa_matched_bounded: Kappa Matched Bounded
- kappa_mis_coeff_pos: Kappa Mis Coeff Pos
- N_trunc_pos: N Trunc Pos
- N_large_enough: N Large Enough
- obs_err_nonneg: Obs Err Nonneg
- eps_eval_pos: Eps Eval Pos
- chain_monotone: Chain Monotone
- rho_matched_pos: Rho Matched Pos
- coeff_matched_nonneg: Coeff Matched Nonneg
- C_decay_pos: C Decay Pos
- factorial_pos: Factorial Pos
- rpm_pos: Rpm Pos
- factorial_bound: Factorial Bound
- trunc_err_nonneg: Trunc Err Nonneg
- coeff_mis_nonneg: Coeff Mis Nonneg
- C_growth_pos: C Growth Pos
- rho_S_pos: Rho S Pos
- rho_cart_nonneg: Rho Cart Nonneg
- s_reg_gt_one: S Reg Gt One
- ell_pos: Ell Pos
- N_pos: N Pos
- C_op_pos: C Op Pos
- inv_sqrt_N_pos: Inv Sqrt N Pos
- op_error_nonneg: Op Error Nonneg
- gap_true_pos: Gap True Pos
- gap_est_pos: Gap Est Pos
- gap_est_error_bound: Gap Est Error Bound

- `sin_angle_nonneg`: Sin Angle Nonneg
- `rho_matched_pos`: Rho Matched Pos
- `rho_mismatched_pos`: Rho Mismatched Pos
- `C_ec_pos`: C Ec Pos
- `ec_bounded_by_g3_quality`: Ec Bounded By G3 Quality
- `eps_pos`: Eps Pos
- `N_matched_pos`: N Matched Pos
- `N_mismatched_pos`: N Mismatched Pos
- `rho_cross_nonneg`: Rho Cross Nonneg
- `rho_min_pos`: Rho Min Pos
- `sigma_pos`: Sigma Pos
- `sigma_sq_pos`: Sigma Sq Pos
- `sigma_sq_half_pos`: Sigma Sq Half Pos
- `C_H_pos`: C H Pos
- `factorial_pos`: Factorial Pos
- `sigma_pow_nonneg`: Sigma Pow Nonneg
- `hermite_coeff_nonneg`: Hermite Coeff Nonneg
- `hermite_factorial_bound`: Hermite Factorial Bound
- `hermite_trunc_nonneg`: Hermite Trunc Nonneg
- `rho_hermite_pos`: Rho Hermite Pos
- `moment_coeff_nonneg`: Moment Coeff Nonneg
- `moment_lower_pos`: Moment Lower Pos
- `kappa_H_pos`: Kappa H Pos
- `kappa_H_bound_pos`: Kappa H Bound Pos
- `kappa_H_bounded`: Kappa H Bounded
- `kappa_M_pos`: Kappa M Pos
- `N_P_pos`: N P Pos
- `c_M_pos`: C M Pos
- `N_P_large_enough`: N P Large Enough
- `kappa_AA_pos`: Kappa Aa Pos
- `kappa_AA_bounded`: Kappa Aa Bounded
- `c_dim_pos`: C Dim Pos
- `N_phase_pos`: N Phase Pos
- `symp_energy_bounded`: Symp Energy Bounded
- `t_final_pos`: T Final Pos
- `product_rho_spatial_bound`: Product Rho Spatial Bound
- `product_rho_temporal_bound`: Product Rho Temporal Bound
- `product_rho_positive`: Product Rho Positive
- `s_reg_pos`: S Reg Pos
- `C_W_pos`: C W Pos
- `C_F_pos`: C F Pos
- `rho_F_bv_bound`: Rho F Bv Bound
- `gibbs_pos`: Gibbs Pos
- `kappa_W_pos`: Kappa W Pos
- `kappa_W_le_bound`: Kappa W Le Bound
- `c_gibbs_pos`: C Gibbs Pos
- `N_trunc_pos`: N Trunc Pos
- `cascade_gap_pos`: Cascade Gap Pos

- proj_err_pos: Proj Err Pos
- lp_total_pos: Lp Total Pos
- lp_partial_pos: Lp Partial Pos
- rho_P_pos: Rho P Pos
- rho_C_nonneg: Rho C Nonneg
- kap_P_pos: Kap P Pos
- kap_P_bound_pos: Kap P Bound Pos
- kappa_pauli_bounded: Kappa Pauli Bounded
- kap_C_pos: Kap C Pos
- n_qubits_pos: N Qubits Pos
- c_q_pos: C Q Pos
- n_large_enough: N Large Enough
- S_P_pos: S P Pos
- S_C_pos: S C Pos
- p_th_pos: P Th Pos
- C_th_pos: C Th Pos
- threshold_from_rho_bound: Threshold From Rho Bound
- delta_pos: Delta Pos
- C_F_pos: C F Pos
- rho_T_nonneg: Rho T Nonneg
- delta_smooth_pos: Delta Smooth Pos
- delta_collision_pos: Delta Collision Pos
- lambda_top_pos: Lambda Top Pos
- lambda_K_pos: Lambda K Pos
- eigenvalue_ordering: Eigenvalue Ordering
- lambda_Kplus1_nonneg: Lambda Kplus1 Nonneg
- gap_K_pos: Gap K Pos
- eta_pos: Eta Pos
- rho_mismatched_nonneg: Rho Mismatched Nonneg
- t_pos: T Pos
- learned_gap_nonneg: Learned Gap Nonneg
- learned_gap_monotone: Learned Gap Monotone
- learned_gap_bounded: Learned Gap Bounded
- kappa_F_pos: Kappa F Pos
- kappa_nat_pos: Kappa Nat Pos
- n_params_pos: N Params Pos
- n_data_pos: N Data Pos
- C_reg_pos: C Reg Pos
- overparam_gap_positive: Overparam Gap Positive
- rho_univ_pos: Rho Univ Pos
- gap_nonneg: Gap Nonneg
- gap_pos_implies_rho_gt_one: Gap Pos Implies Rho Gt One
- rho_mis_univ_nonneg: Rho Mis Univ Nonneg
- universal_mis_bound: Universal Mis Bound

Established Facts

- factorial: Factorial

- factorial_zero: Factorial Zero
- rho_pow_matched: Rho Pow Matched
- threshold_def: Threshold Def
- sigma_sq_def: Sigma Sq Def
- factorial : Factorial
- sigma_pow: Sigma Pow
- bc_in_problem_def: Bc In Problem Def
- rho_fourier_eq_exp_delta: Rho Fourier Eq Exp Delta
- F_exp_zero_one: Exp Zero One
- F_exp_monotone: Exp Monotone
- gap_K_def: Gap K Def
- rho_matched_def: Rho Matched Def
- rho_t_def: Rho T Def

11. Proof Architecture

All proofs are implemented in the Platonic kernel (elysium/fields/grade3_latent_algebra/).

File	Role
grade3_algebra_proof.py	
spherical_harmonics_proof.py	
constructive_bstar_proof.py	
ec_grade3_bridge_proof.py	
askey_scheme_proof.py	
hermite_instance_proof.py	
grade4_termination_proof.py	
wavelet_multiresolution_proof.py	
pauli_quantum_proof.py	
fourier_orbit_proof.py	
neural_feature_proof.py	
universality_proof.py	

12. Discussion

References