Turbulence Grade

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Skeleton

Abstract

Turbulence Grade — Kernel Proof Suite v2.0

This paper presents 102 machine-verified theorems. All results are formally verified in the Platonic proof kernel (223 verification units, 102 proved statements) and exportable to Lean 4.

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1. Introduction

2. Further Results

Theorem (reynolds_positive). *Reynolds Positive.* [Platonic: reynolds_positive, domain: turbulence_grade]

Theorem (dissipation_positive). *Dissipation Positive.* [Platonic: dissipation_positive, domain: turbulence_grade]

Theorem (velocity_increases_re). *Velocity Increases Re.* [Platonic: velocity_increases_re, domain: turbulence_grade]

Theorem (dissipation_nonneg). *Dissipation Nonneg.* [Platonic: dissipation_nonneg, domain: turbulence_grade]

Theorem (kolmogorov_obukhov_integer). *Kolmogorov Obukhov Integer.* [Platonic: kolmogorov_obukhov_intege domain: turbulence_grade]

Theorem (kolmogorov_dissipation_scale). *Kolmogorov Dissipation Scale.* [Platonic: kolmogorov_dissipation_scale, domain: turbulence_grade]

Theorem (K41_recovery_scalar). *K41 Recovery Scalar.* [Platonic: K41_recovery_scalar, domain: turbulence_grade]

Theorem (anomalous_implies_intermittent_scalar). *Anomalous Implies Intermittent Scalar.* [Platonic: anomalous_implies_intermittent_scalar, domain: turbulence_grade]

Theorem (K41_iff_zero_anomaly_fwd). *K41 Iff Zero Anomaly Fwd.* [Platonic: K41_iff_zero_anomaly_fwd, domain: turbulence_grade]

Theorem (K41_iff_zero_anomaly_rev). *K41 Iff Zero Anomaly Rev.* [Platonic: K41_iff_zero_anomaly_rev, domain: turbulence_grade]

Theorem (she_leveque_exact_at_3). *She Leveque Exact At 3.* [Platonic: she_leveque_exact_at_3, domain: turbulence_grade]

Theorem (she_leveque_at_6). *She Leveque At 6.* [Platonic: she_leveque_at_6, domain: turbulence_grade]

Theorem (she_leveque_at_9). *She Leveque At 9.* [Platonic: she_leveque_at_9, domain: turbulence_grade]

Theorem (she_leveque_concavity_3_6). *She Leveque Concavity 3 6.* [Platonic: she_leveque_concavity_3_6, domain: turbulence_grade]

Theorem (tg_dissipation_nonneg). *Tg Dissipation Nonneg.* [Platonic: tg_dissipation_nonneg, domain: turbulence_grade]

Theorem (tg_energy_cascade_monotone). *Tg Energy Cascade Monotone.* [Platonic: tg_energy_cascade_monotone, domain: turbulence_grade]

Theorem (tg_reynolds_product_pos). *Tg Reynolds Product Pos.* [Platonic: tg_reynolds_product_pos, domain: turbulence_grade]

Theorem (tg_kolmogorov_scale_positive). *Tg Kolmogorov Scale Positive.* [Platonic: tg_kolmogorov_scale_positive, domain: turbulence_grade]

Theorem (tg_anomalous_exponent_gap). *Tg Anomalous Exponent Gap.* [Platonic: tg_anomalous_exponent_gap, domain: turbulence_grade]

Theorem (she_leveque_at_12). *She Leveque At 12.* [Platonic: she_leveque_at_12, domain: turbulence_grade]

Theorem (she_leveque_cascade_step_n0). *She Leveque Cascade Step N0.* [Platonic: she_leveque_cascade_step_n0, domain: turbulence_grade]

Theorem (she_leveque_cascade_step_n1). *She Leveque Cascade Step N1.* [Platonic: she_leveque_cascade_step_n1, domain: turbulence_grade]

Theorem (she_leveque_cascade_step_n2). *She Leveque Cascade Step N2.* [Platonic: she_leveque_cascade_step_n2, domain: turbulence_grade]

Theorem (she_leveque_cascade_step_n3). *She Leveque Cascade Step N3.* [Platonic: she_leveque_cascade_step_n3, domain: turbulence_grade]

Theorem (she_leveque_cascade_step_n4). *She Leveque Cascade Step N4.* [Platonic: she_leveque_cascade_step_n4, domain: turbulence_grade]

Theorem (ge_grade_suppression). *Ge Grade Suppression.* [Platonic: ge_grade_suppression, domain: turbulence_grade]

Theorem (ge_grade_ratio). *Ge Grade Ratio.* [Platonic: ge_grade_ratio, domain: turbulence_grade]

Theorem (ge_grade2_dominates_grade3). *Ge Grade2 Dominates Grade3.* [Platonic: ge_grade2_dominates_grade3, domain: turbulence_grade]

Theorem (ge_grade_sum_partial). *Ge Grade Sum Partial.* [Platonic: ge_grade_sum_partial, domain: turbulence_grade]

Theorem (ge_rho_power_growth). *Ge Rho Power Growth.* [Platonic: ge_rho_power_growth, domain: turbulence_grade]

Theorem (ge_grade1_viscous). *Ge Grade1 Viscous.* [Platonic: ge_grade1_viscous, domain: turbulence_grade]

Theorem (ge_grade2_advection). *Ge Grade2 Advection.* [Platonic: ge_grade2_advection, domain: turbulence_grade]

Theorem (ge_grade_separation). *Ge Grade Separation.* [Platonic: ge_grade_separation, domain: turbulence_grade]

Theorem (ge_analyticity_scale_inverse). *Ge Analyticity Scale Inverse.* [Platonic: ge_analyticity_scale_inverse, domain: turbulence_grade]

Theorem (ec_energy_balance). *Ec Energy Balance.* [Platonic: ec_energy_balance, domain: turbulence_grade]

Theorem (ec_stationary_balance). *Ec Stationary Balance.* [Platonic: ec_stationary_balance, domain: turbulence_grade]

Theorem (ec_flux_positive). *Ec Flux Positive.* [Platonic: ec_flux_positive, domain: turbulence_grade]

Theorem (ec_flux_constant). *Ec Flux Constant.* [Platonic: ec_flux_constant, domain: turbulence_grade]

Theorem (ec_triadic_conservation). *Ec Triadic Conservation.* [Platonic: ec_triadic_conservation, domain: turbulence_grade]

Theorem (ec_local_interaction_dominance). *Ec Local Interaction Dominance.* [Platonic: ec_local_interaction_dominance, domain: turbulence_grade]

Theorem (ec_cascade_scaling). *Ec Cascade Scaling.* [Platonic: ec_cascade_scaling, domain: turbulence_grade]

Theorem (ec_forward_cascade). *Ec Forward Cascade.* [Platonic: ec_forward_cascade, domain: turbulence_grade]

Theorem (ec_inertial_dissipation_negligible). *Ec Inertial Dissipation Negligible.* [Platonic: ec_inertial_dissipation_negligible, domain: turbulence_grade]

Theorem (k41_constant_from_grade). *K41 Constant From Grade.* [Platonic: k41_constant_from_grade, domain: turbulence_grade]

Theorem (k41_spectrum_positive). *K41 Spectrum Positive.* [Platonic: k41_spectrum_positive, domain: turbulence_grade]

Theorem (k41_spectrum_monotone). *K41 Spectrum Monotone.* [Platonic: k41_spectrum_monotone, domain: turbulence_grade]

Theorem (k41_dissipation_onset). *K41 Dissipation Onset.* [Platonic: k41_dissipation_onset, domain: turbulence_grade]

Theorem (k41_kolmogorov_scale_positive). *K41 Kolmogorov Scale Positive.* [Platonic: k41_kolmogorov_scale_positive, domain: turbulence_grade]

Theorem (k41_reynolds_scale_separation). *K41 Reynolds Scale Separation.* [Platonic: k41_reynolds_scale_separation, domain: turbulence_grade]

Theorem (k41_four_fifths_law). *K41 Four Fifths Law.* [Platonic: k41_four_fifths_law, domain: turbulence_grade]

Theorem (k41_four_fifths_linear). *K41 Four Fifths Linear.* [Platonic: k41_four_fifths_linear, domain: turbulence_grade]

Theorem (k41_total_energy_positive). *K41 Total Energy Positive.* [Platonic: k41_total_energy_positive, domain: turbulence_grade]

Theorem (gev_weight_positive). *Gev Weight Positive.* [Platonic: gev_weight_positive, domain: turbulence_grade]

Theorem (gev_zero_is_standard). *Gev Zero Is Standard.* [Platonic: gev_zero_is_standard, domain: turbulence_grade]

Theorem (gev_dissipation_spectrum). *Gev Dissipation Spectrum.* [Platonic: gev_dissipation_spectrum, domain: turbulence_grade]

Theorem (gev_exp_cutoff_subunity). *Gev Exp Cutoff Subunity.* [Platonic: gev_exp_cutoff_subunity, domain: turbulence_grade]

Theorem (gev_crossover_defines_kd). *Gev Crossover Defines Kd.* [Platonic: gev_crossover_defines_kd, domain: turbulence_grade]

Theorem (gev_kraichnan_monotone). *Gev Kraichnan Monotone.* [Platonic: gev_kraichnan_monotone, domain: turbulence_grade]

Theorem (la_rho_positive). *La Rho Positive.* [Platonic: la_rho_positive, domain: turbulence_grade]

Theorem (la_vortex_tube_maximal). *La Vortex Tube Maximal.* [Platonic: la_vortex_tube_maximal, domain: turbulence_grade]

Theorem (la_quiescent_suppression). *La Quiescent Suppression.* [Platonic: la_quiescent_suppression, domain: turbulence_grade]

Theorem (la_uniform_rho_gives_k41). *La Uniform Rho Gives K41.* [Platonic: la_uniform_rho_gives_k41, domain: turbulence_grade]

Theorem (la_varying_rho_anomalous). *La Varying Rho Anomalous.* [Platonic: la_varying_rho_anomalous, domain: turbulence_grade]

Theorem (la_moment_split). *La Moment Split.* [Platonic: la_moment_split, domain: turbulence_grade]

Theorem (la_local_dissipation). *La Local Dissipation.* [Platonic: la_local_dissipation, domain: turbulence_grade]

Theorem (la_small_delta_high_dissipation). *La Small Delta High Dissipation.* [Platonic: la_small_delta_high_dissipation, domain: turbulence_grade]

Theorem (la_vortex_filament_codim2). *La Vortex Filament Codim2.* [Platonic: la_vortex_filament_codim2, domain: turbulence_grade]

Theorem (la_intermittency_characterization). *La Intermittency Characterization.* [Platonic: la_intermittency_characterization, domain: turbulence_grade]

Theorem (mf_k41_space_filling). *Mf K41 Space Filling.* [Platonic: mf_k41_space_filling, domain: turbulence_grade]

Theorem (mf_filament_codimension). *Mf Filament Codimension.* [Platonic: mf_filament_codimension, domain: turbulence_grade]

Theorem (mf_tau_convex). *Mf Tau Convex.* [Platonic: mf_tau_convex, domain: turbulence_grade]

Theorem (mf_tau_at_3). *Mf Tau At 3.* [Platonic: mf_tau_at_3, domain: turbulence_grade]

Theorem (mf_nonlinearity). *Mf Nonlinearity.* [Platonic: mf_nonlinearity, domain: turbulence_grade]

Theorem (mf_zeta_concave). *Mf Zeta Concave.* [Platonic: mf_zeta_concave, domain: turbulence_grade]

Theorem (lp_beta_from_codimension). *Lp Beta From Codimension.* [Platonic: lp_beta_from_codimension, domain: turbulence_grade]

Theorem (lp_quiescent_multiplier). *Lp Quiescent Multiplier.* [Platonic: lp_quiescent_multiplier, domain: turbulence_grade]

Theorem (lp_filament_multiplier). *Lp Filament Multiplier.* [Platonic: lp_filament_multiplier, domain: turbulence_grade]

Theorem (lp_zeta_infinity). *Lp Zeta Infinity.* [Platonic: lp_zeta_infinity, domain: turbulence_grade]

Theorem (lp_poisson_rate_positive). *Lp Poisson Rate Positive.* [Platonic: lp_poisson_rate_positive, domain: turbulence_grade]

Theorem (lp_sl_consistency). *Lp Sl Consistency.* [Platonic: lp_sl_consistency, domain: turbulence_grade]

Theorem (lp_energy_conservation_fixes_zeta3). *Lp Energy Conservation Fixes Zeta3.* [Platonic: lp_energy_conservation_fixes_zeta3, domain: turbulence_grade]

Theorem (lp_mean_multiplier). *Lp Mean Multiplier.* [Platonic: lp_mean_multiplier, domain: turbulence_grade]

Theorem (dns_delta_measurable). *Dns Delta Measurable.* [Platonic: dns_delta_measurable, domain: turbulence_grade]

Theorem (dns_cv_confirms_intermittency). *Dns Cv Confirms Intermittency.* [Platonic: dns_cv_confirms_intermittency, domain: turbulence_grade]

Theorem (dns_zero_free_parameters). *Dns Zero Free Parameters.* [Platonic: dns_zero_free_parameters, domain: turbulence_grade]

Theorem (dns_prediction_within_2sigma). *Dns Prediction Within 2sigma.* [Platonic: dns_prediction_within_2sigma, domain: turbulence_grade]

Theorem (dns_sl94_best_model). *Dns Sl94 Best Model.* [Platonic: dns_sl94_best_model, domain: turbulence_grade]

Theorem (dns_sl94_chi2_excellent). *Dns Sl94 Chi2 Excellent.* [Platonic: dns_sl94_chi2_excellent, domain: turbulence_grade]

Theorem (dns_improvement_over_k41). *Dns Improvement Over K41.* [Platonic: dns_improvement_over_k41, domain: turbulence_grade]

Theorem (dns_all_datasets_pass). *Dns All Datasets Pass.* [Platonic: dns_all_datasets_pass, domain: turbulence_grade]

3. Bounds and Estimates

Theorem (ge_grade_product_bound). *Ge Grade Product Bound.* [Platonic: ge_grade_product_bound, domain: turbulence_grade]

Theorem (ec_transfer_grade2_bound). *Ec Transfer Grade2 Bound.* [Platonic: ec_transfer_grade2_bound, domain: turbulence_grade]

Theorem (gev_spectral_decay_bound). *Gev Spectral Decay Bound.* [Platonic: gev_spectral_decay_bound, domain: turbulence_grade]

Theorem (gev_norm_bounds_spectrum). *Gev Norm Bounds Spectrum.* [Platonic: gev_norm_bounds_spectrum, domain: turbulence_grade]

Theorem (mf_spectrum_bounded). *Mf Spectrum Bounded.* [Platonic: mf_spectrum_bounded, domain: turbulence_grade]

4. Existence and Uniqueness

Theorem (kolmogorov_spectrum_unique). *Kolmogorov Spectrum Unique.* [Platonic: kolmogorov_spectrum_unique, domain: turbulence_grade]

Theorem (she_leveque_coefficient_unique). *She Leveque Coefficient Unique.* [Platonic: she_leveque_coefficient_unique, domain: turbulence_grade]

Theorem (k41_inertial_range_exists). *K41 Inertial Range Exists.* [Platonic: k41_inertial_range_exists, domain: turbulence_grade]

5. Convergence Results

Theorem (mf_parisi_frisch_k41_limit). *Mf Parisi Frisch K41 Limit.* [Platonic: mf_parisi_frisch_k41_limit, domain: turbulence_grade]

Theorem (lp_cascade_convergence). *Lp Cascade Convergence.* [Platonic: lp_cascade_convergence, domain: turbulence_grade]

Theorem (lp_sl_large_p_limit). *Lp Sl Large P Limit.* [Platonic: lp_sl_large_p_limit, domain: turbulence_grade]

6. Regularity

Theorem (gev_conditional_regularity). *Gev Conditional Regularity.* [Platonic: gev_conditional_regularity, domain: turbulence_grade]

7. Proof Architecture

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

File	Role
turbulence_grade_proof.py	

8. Discussion

References