CURRICULUM VITÆ

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Education

Ph.D.	1995	University of Rochester and Brookhaven National Laboratory
M.S.	1992	University of Rochester, Rochester, NY
RNDr	1989	Comenius University, Bratislava, Slovakia

Selected Professional Experience

2021-date	Scientist Dept of Theoretical Physics, Nuclear Physics Institute, Řež (Prague)
2020-date	Adjunct Associate Professor Department of Physics, University of Kentucky, Lexington, KY
2017-2020	Research Associate Professor Department of Physics, University of Kentucky, Lexington, KY
2008-2020	Research Associate Professor (proprietary research) Department of Anesthesiology, University of Kentucky, KY
2003-2008	Research Assistant Professor Department of Physics, University of Kentucky, Lexington, KY
1997-2000	Postdoctoral Research Associate University of Virginia, Charlottesville, VA
1994-1997	Postdoctoral Research Associate Supercomputer Computations Research Institute, Tallahassee, FL
1992-1994	Graduate Research Assistant (particle physics theory) Brookhaven National Laboratory, Upton, NY
1990-1991	Graduate Research Assistant (particle physics experiment) University of Rochester and Brookhaven National Laboratory

Research Areas/Keywords

theoretical particle and nuclear physics, electrophysiology of brain, neuromonitoring, EEG and evoked responses, adequacy of anesthesia, vacuum structure of strong interactions, QCD phase transition, lattice field theory, depression in epilepsy, critical phenomena, computational physics, Monte Carlo simulations, chiral symmetry, biosignal analysis, statistical methods, quantum information, applied mathematics, anesthesia education research

Selected Skills

- extensive background in mathematics and theoretical physics
- extensive background in research: academic and proprietary
- programming, statistical data analysis and scientific modeling
- computation and information theory (including quantum aspects)
- acquisition and analysis of human biosignals
- anesthesia and neuromonitoring
- EEG/evoked potentials hardware & software
- university teaching (includes devising online instruction for large classes)

Short Description of Current Research Focus

(1) Thermal QCD Transition and its IR Phase

Understanding the properties of QCD at varied temperatures (T) is important for reconstructing the thermal history of the universe, as well as for guiding the current experiments at RHIC/LHC and interpreting their results. The central issue is to understand the regime separating the low-T world of hadrons and the conjectured high-T realm of essentially free quarks and gluons. This "QCD transition" was (and overwhelmingly still is) assumed to be represented by a single point "T_c" on the temperature scale, most commonly identified with the point of chiral crossover ($T_c \approx 155\,\mathrm{MeV}$).

However, the discovery of near-perfect fluid at RHIC/LHC created room for more intricate scenarios. Indeed, the experimental data implies that the new medium is strongly interacting and doesn't fit either of the standard low-T/high-T interpretations.

In Ref. [44] A. Alexandru and I proposed, based on lattice simulations, that the near-perfect fluid is in fact a distinct phase of thermal QCD, characterized by the restoration of scale invariance in the infrared (IR phase). Our picture accommodates the conventional crossover but also predicts a true phase transition into IR phase at higher temperature $200 < T_{\mathrm{IR}} < 250\,\mathrm{MeV}$. Another phase transition at $T_{\mathrm{UV}} > 1\,\mathrm{GeV}$ then possibly marks the onset of high-T regime featuring weakly interacting quark-gluon plasma.

My current research focuses on describing various new aspects of IR phase, verifying some of the original predictions, and computing $T_{\rm IR}$ with better accuracy. Our most recent works [45,47] revealed a surprising hierarchy of integer dimensions for Dirac modes in IR phase, suggesting its topological nature. It also clarified the role of Anderson-like Dirac localization physics in the process of IR scale invariance restoration.

(2) Effective Numbers and their Quantum Uses

In quantitative analysis it is frequently desirable to count objects endowed with additive weights such as masses or probabilities. For example, when describing the Solar System, one may want to specify the number of celestial bodies orbiting the Sun. However, since the masses of these objects vary widely, simply specifying their count is less informative for gravitational purposes than a suitable *effective number* to which objects contribute according to their mass. Similarly, in the quantum realm, one may need the effective count of possible measurement outcomes or, equivalently, the effective number of "identities" a quantum state can assume upon given measurement [42,46,40p]. Among other things, such effective counting could be used to evaluate the efficiency of a quantum algorithm.

Somewhat surprisingly, it turns out that a meaningful effective counting scheme of such type exists [42]. Indeed, with Robert Mendris we constructed the *Effective Number Theory* (ENT) which formalizes the relevant concept and produces this solution. Moreover, extending the ENT to incorporate the notion of effective subset leads to a unique concept of effective Hausdorff-like dimension and a novel description of localization [45,5e,48]. These new tools have already proved useful in the context of thermal QCD and its IR phase [45] (see above), and will be further utilized for related purposes. In addition, a major effort (with Peter Markoš) is currently under way to characterize Anderson localization transitions in this manner and to demonstrate the physical utility of this description [48].

The use of ENT that is most innately quantum stems from its ability to naturally accommodate quantum correlations among objects [46]. A prototypical problem this allows ENT to solve is to determine the number of states effectively comprising a density matrix. The latter is a basis-independent quantifier referred to as *quantum effective number*. Given its meaning, it can be used to construct a novel measure-based characteristic of entanglement [46]. Developing this approach into a practical tool to study new features of quantum field theory and the information/efficiency aspects of quantum computing is a second major focus of my present research.

Brief Summary of Recent Research Topics

- Effective description and monitoring of human central nervous system for objective assessment of general anesthesia, mental health and pain; proprietary.
- Developing novel biosignal analysis methods based non-Pearson correlations (EEG, Evoked Potentials, EMG, MRI/fMRI signals); proprietary.
- Vacuum structure of strong interactions and its topology via lattice QCD
- Anesthesia resident education research

Brief Summary of Past Research Topics

- Computation of hadronic properties using lattice QCD techniques
- Theoretical work on the implementation of chiral symmetry in lattice-regularized field theory (Ginsparg-Wilson fermions, domain-wall fermions)
- Phase structure of lattice gauge theories with Wilson fermions (parity-flavor violating phases and related topics)
- Conceptual and performance issues in Monte Carlo simulations of lattice QCD/spin systems (overrelaxation, hybrid molecular dynamics algorithms, finite baryon density)
- Development and application of the Method of Recursive Counting for exact solutions of finite statistical systems
- Quantum description of J/ψ dissolution in the quark-gluon plasma environment
- Development of the Steepest Descent Method in Hilbert space for diagonalization of many-body Hamiltonians

Selected Teaching Experience

- General University Physics: online & in class; lecturer
- Classical Electromagnetism, Quantum Mechanics (for physics majors); lecturer
- Introductory Labs; laboratory instructor
- Problem Solving in Physics (preparation of students for Physics Olympiad); instructor

Recent Academic Service

- Editorial Board, Acta Physica Slovaca, 2006–2018

Citation Record

- Particle Physics works cited 2,737 times, 53 citations/refereed work, h_{HEP}=24
  Source: Stanford Public Information Retrieval System (Oct 25, 2021)

LIST OF PUBLICATIONS

Works Published in Refereed Journals:

[1] I. Horváth, P. Lichard, R. Lietava A. Nogová and J. Pišút: *On the Time Dependence of J/Psi Suppression by the Quark-Gluon Plasma.* Phys. Lett. **B214** (1988), 237.

[2] I. Horváth: *The Steepest Descent Method Calculation of Ground and Excited State Energies in (2+1) QED on a One Plaquette Lattice.*
Acta Physica Slovaca **39** (1989) 137.

[3] J. Ftáčnik and I. Horváth: *Computation of Energy Levels and Wave Functions of Ground and Excited States of Simple Systems by the Steepest Descent Method.*
Phys. Rev. **D40** (1989), 642.

[4] V. Černý, I. Horváth, R. Lietava, A. Nogová and J. Pišút: *On the Concept of the J/Psi Formation Time in Quark-Gluon Plasma.* Z. Phys. **C46** (1990), 481.

[5] P.F. Bedaque, I. Horváth and S.G. Rajeev: *Two-Dimensional Baryons in Large N Limit.* Mod. Phys. Let. **A7** (1992), 3347.

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Phys. Rev. **D50** (1994), 2297.

[9] I. Horváth: *The Phase Structure of the Schwinger Model on the Lattice with Wilson Fermions in the Hartree-Fock Approximation.* Phys. Rev. **D53** (1996), 3808.

[10] R.G. Edwards, I. Horváth and A.D. Kennedy: *Instabilities and Non-Reversibility of Molecular Dynamics Trajectories.* Nucl. Phys. **B484** (1997), 375.

[11] I. Horváth and A.D. Kennedy: *The Local Hybrid Monte Carlo Algorithm for Free Field Theory: Reexamining Overrelaxation.* Nucl. Phys. **B510** (1998), 367.

[12] I. Horváth: *Ginsparg-Wilson Relation and Ultralocality.*
Phys. Rev. Lett. **81** (1998), 4063.

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[14] I. Horváth, C. T. Balwe and R. Mendris: *Strong Non-Ultralocality of Ginsparg-Wilson Fermionic Actions.* Nucl. Phys. **B 599** (2001) 283.

[15] I. Horváth, N. Isgur, J. McCune and H.B. Thacker: *Evidence Against Instanton Dominance of Low Energy QCD.* Phys. Rev. **D65** (2001) 014502.

[16] S.J. Dong, T. Draper, I. Horváth, F.X. Lee, K.F. Liu and J.B. Zhang: *Chiral Properties of Pseudoscalar Mesons on a Quenched* 20^4 *Lattice with Overlap Fermions.*
Phys. Rev. **D65** (2002) 054507.

[17] B. Joó, I. Horváth, K.F. Liu: *The Kentucky Noisy Monte Carlo Algorithm for Wilson Dynamical Fermions.* Phys. Rev. **D67** (2003) 074505.

[18] I. Horváth, S.J. Dong, T. Draper, N. Isgur, F.X. Lee, K.F. Liu, J. McCune, H.B. Thacker and J.B. Zhang: *Local Chirality of Low-Lying Dirac Eigenmodes and the Instanton Liquid Model.* Phys. Rev. **D66** (2002) 034501.

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On the Local Structure of Topological Charge Fluctuations in QCD.
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Phys. Rev. **D70** (2004) 074508.

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Nucl. Phys. **B710** (2005), 464; Erratum-ibid. **B714** (2005), 175.

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[36] A. Alexandru, T. Draper, I. Horváth, T. Streuer: *The Analysis of Space–Time Structure in QCD Vacuum II: Dynamics of Polarization and the Absolute X–Distribution.* Annals Phys. **326** (2011) 1941.

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[40] A. Alexandru, I. Horváth: *Phases of SU(3) Gauge Theories with Fundamental Quarks via Dirac Spectral Density.* Phys. Rev. **D92** (2015) 045038. [arXiv:1502.07732]

[41] A. Alexandru, I. Horváth: *Locality and Efficient Evaluation of Lattice Composite Fields: Overlap-Based Gauge Operators.* Phys. Rev. **D95** (2017) 014509. [arXiv:1611.04926]

[42] I. Horváth, R. Mendris: *Effective Number Theory: Counting the Identities of a Quantum State.* Entropy **22** (2020) 1273. [arXiv:1807.03995]

[43] A. Rebel, A. DiLorenzo, D. Nguyen, I. Horváth, M.D. McEvoy, R.Y. Fragneto, J.S. Dority, G.L. Rose, R.M. Schell: *Should Objective Structured Clinical Examinations (OSCEs) Assist the Clinical Competency Committee in Assigning Anesthesiology Milestones Competency?* Anesthesia & Analgesia 129(1):226-234, Jul 2019.

[44] A. Alexandru, I. Horváth: *A possible New Phase of Thermal QCD.* Phys. Rev. **D100** (2019) 094507. [arXiv:1906.08047]

[45] A. Alexandru, I. Horváth: *Unusual Features of QCD Low-Energy Modes in IR Phase.* Phys. Rev. Lett. **127** (2021) 052303. [arXiv:2103.05607]

[46] I. Horváth: *The Measure Aspect of Quantum Uncertainty, of Entanglement, and Respective Entropies.* Quantum Rep **3** (2021) 534. [arXiv:1809.07249].

[47] A. Alexandru, I. Horváth: *Anderson Metal-to-Critical Transition in QCD.* Submitted to Phys. Rev. Lett. [arXiv:2110.04833].

[48] I. Horváth, P. Markoš: *Super-Universality in Anderson Localization.* Submitted to Phys. Rev. Lett. [arXiv:2110.11266].

Works Published in Proceedings of Scientific Meetings:

[1p] I. Horváth: *Determination of Wave Functions of the Ground and the Excited States of Simple Systems by Steepest Descent Method.*
In *Frontiers in Nonperturbative Field Theory* (World Scientific, 1989), 322-327; Proceedings of the International Conference, Aug 18-23, 1988, Eger, Hungary.

[2p] I. Horváth, R. Lietava, A. Nogová and J. Pišút: *The Concept of J/Psi Formation Time and the P(t) dependence of J/Psi suppression.*
In *Hadron Structure '89* (Institute of Physics, Bratislava, 1989), 296-302; Proceedings of the International Conference, Sep 25-28, 1989, Smolenice, Czechoslovakia.

[3p] M. Creutz, I. Horváth and R. Mendris: *The Method of Recursive Counting: Can One Go Further?* Nucl. Phys. **B** (Proc. Suppl.) **34** (1994), 583.

[4p] M. Creutz and I. Horváth: *Surface Modes and Chiral Symmetry (Wilson Fermions in a Box).* Nucl. Phys. **B** (Proc. Suppl.) **34** (1994), 583.

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In *Multiscale Phenomena and Their Simulation* (World Scientific, 1997), 184-188; Proceedings of the International Conference, Sep 30 - Oct 4, 1996, Bielefeld, Germany.

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[13p] S.J. Dong, T. Draper, I. Horváth, N. Isgur, F.X. Lee, J. McCune, K.F. Liu, J.B. Zhang and H.B. Thacker: *Topological Charge Fluctuations and Low-Lying Dirac Eigenmodes.* Nucl. Phys. **B** (Proc. Suppl.) **106** (2002) 563.

[14p] S.J. Dong, T. Draper, I. Horváth, F.X. Lee and J.B. Zhang: *Quenched Chiral Behavior of Hadrons with Overlap Fermions.* Nucl. Phys. **B** (Proc. Suppl.) **106** (2002) 275.

[15p] S.J. Dong, T. Draper, I. Horváth, F.X. Lee and J.B. Zhang: *Pion Decay Constant, Z_A and Chiral Log from Overlap Fermions.* Nucl. Phys. **B** (Proc. Suppl.) **106** (2002) 341.

[16p] I. Horváth, S.J. Dong, T. Draper, F.X. Lee, H.B. Thacker and J.B. Zhang: *Low-Lying Dirac Eigenmodes, Topological Charge Fluctuations and the Instanton Liquid Model.* In *Confinement, Topology and Other Non-Perturbative Aspects of QCD* (Kluwer Academic Publishers, 2002) 213-224.

[17p] I. Horváth, S.J. Dong, T. Draper, F.X. Lee, H.B. Thacker and J.B. Zhang: *The local structure of topological charge fluctuations in QCD.* Nucl. Phys. **B** (Proc. Suppl.) **119** (2003) 688.

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[19p] S.J. Dong, T. Draper, I. Horváth, F.X. Lee, N. Mathur and J.B. Zhang: *Empirical Baye's Method and Test in Very Light Quark Range from the Overlap Lattice QCD.* Nucl. Phys. **B** (Proc. Suppl.) **119** (2003) 248.

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[21p] H. Thacker, S.J. Dong, T. Draper, I. Horváth, F.X. Lee, K.F. Liu and J.B. Zhang: *Topological Charge Correlators, Spectral Bounds, and Contact Terms.* Nucl. Phys. **B** (Proc. Suppl.) **119** (2003) 685.

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[27p] A. Alexandru, M. Faber, I. Horváth and K.F. Liu: *Progress on a canonical finite density algorithm.* Nucl. Phys. **B** (Proc. Suppl.) 140, (2005) 517.

[28p] S. Tamhankar, A. Alexandru, Y. Chen, S.J. Dong, T. Draper, I. Horváth, F.X. Lee, K.F. Liu, N. Mathur and J.B. Zhang: *Charmonium Spectrum from Quenched QCD with Overlap Fermions.* Nucl. Phys. **B** (Proc. Suppl.) 140, (2005) 434.

[29p] T. Draper, N. Mathur, J.B. Zhang, A. Alexandru, Y. Chen, S.J. Dong, I. Horváth, F.X. Lee, S. Tamhankar: *Locality and Scaling of Quenched Overlap Fermions.* Proc. Sci. **LAT2005** (2005) 120. [`hep-lat/0510075`]

[30p] I. Horváth: *Coherent lattice QCD.* Proc. Sci. **LAT2006** (2006) 53. [`hep-lat/0610121`]

[31p] I. Horváth, A. Alexandru, T. Streuer: *Dominance of Sign Geometry and the Homogeneity of the Fundamental Topological Structure.* PoS (LATTICE 2008) (2008) 261. [`arXiv:0809.2834`]

[32p] A. Alexandru, T. Draper, I. Horváth, T. Streuer: *Absolute Measure of Local Chirality and the Chiral Polarization Scale of the QCD Vacuum.* PoS (LATTICE 2010) (2010) 82. [`arXiv:1010.5474`]

[33p] A. Alexandru, I. Horváth: *Absolute X-distribution and Self-Duality.* PoS (LATTICE 2011) (2011) 268. [`arXiv:1111.3897`]

[34p] A. Alexandru, I. Horváth: *Chiral Polarization Scale at Finite Temperature.* PoS (LATTICE 2012) (2012) 210. [arXiv:1211.2601]

[35p] A. Alexandru, I. Horváth: *Chiral Polarization Scale of the QCD Vacuum and Spontaneous Chiral Symmetry Breaking.* Journal of Physics: Conference Series **432** (2013) 012034. [arXiv:1211.3728]

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[39p] A. Alexandru, I. Horváth: *Classifying the Phases of Gauge Theories by Spectral Density of Probing Chiral Quarks.* PoS (LATTICE 2015) (2015) 314. [arXiv:1511.09370]

[40p] I. Horváth, R. Mendris: *A Different Angle on Quantum Uncertainty.* Proceedings **2019**, 13(1), 8.

Works Published Electronically:

[1e] Y. Chen, S.J. Dong, T. Draper, I. Horváth, K.F. Liu, N. Mathur, S. Tamhankar, C. Srinivasan, F.X. Lee and J.B. Zhang: *The Sequential Empirical Bayes Method: An Adaptive Constrained-Curve Fitting Algorithm for Lattice QCD.* [hep-lat/0405001]

[2e] I. Horváth: *A Framework for Systematic Study of QCD Vacuum Structure I: Kolmogorov Entropy and the Principle of Chiral Ordering.* [hep-lat/0605008]

[3e] I. Horváth: *A Framework for Systematic Study of QCD Vacuum Structure II: Coherent Lattice QCD.* [hep-lat/0607031]

[4e] T. Draper, N. Mathur, J. Zhang, A. Alexandru, Y. Chen, S.J. Dong, I. Horváth, F.X. Lee, K.F. Liu and S. Tamhankar: *On the Locality and Scaling of Overlap Fermions at Coarse Lattice Spacings.* [hep-lat/0609034]

[5e] I. Horváth and R. Mendris: *Effective Dimension Theory.* In preparation.

Other Works:

[1o] I. Horváth, F. Lobkowicz, G. Osborne and J. Soong:
Magnetic Transformers for the SDC. SDC-90-00069, 1990.

[2o] I. Horváth, F. Lobkowicz and G. Osborne: *Transformers in the SDC Coil.*
UR-1221, SDC-91-00042, 1991.

[3o] I. Horváth: *Comment on* hep-lat/9901005 v1-v3 *by W. Bietenholz.*
hep-lat/0003008

Selected Recent Presentations and Speaking Engagements

- University of Maryland, Maryland Center for Fundamental Physics, 22 Apr 2015. **Invited.**
- Simons Center Workshop: *"Gauge Field Topology: From Lattice Simulations and Solvable Models to Experiment"*, Simons Center for Geometry and Physics, State University of New York, Stony Brook, 17-21 Aug 2015. **Invited.**
- Kavli Institute for Theoretical Physics Program: *"Lattice Gauge Theory for the LHC and Beyond"*, Kavli Institute for Theoretical Physics, University of California, Santa Barbara, 4 Aug - 25 Sep 2015. **Invited.**
- Albert Einstein Institute, University of Bern, 15 Jun 2017. **Invited.**
- Brookhaven National Laboratory, Upton, NY, 6 Sep 2018. **Invited.** (quantum IT)
- Brookhaven National Laboratory, Upton, NY, 7 Sep 2018. **Invited.** (nuclear theory)
- Institute of High Energy Physics, Chinese Academy of Sciences, Beijing, China. 13 Jun 2019. **Invited.**
- University of Toronto, Department of Physics, Toronto, Canada. 13 Sep 2019. **Invited.**