MARC VUFFRAY

RESEARCH SCIENTIST • LANL THEORETICAL DIVISION

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PROFILE

I am staff research scientist in the Theoretical Division at the Los Alamos National Laboratory. I am part of the Advanced Network Science Initiative and of the Quantum and Condensed Matter Physics group. My background is both in Computer Science and Physics. I conduct research in Quantum Computing, Statistical Learning, and Energy Networks.

RESEARCH INTERESTS

My research spans theoretical and applied aspects of **quantum computing**, with a particular focus on **quantum algorithms**, **quantum computing applications** and their integration into emerging fault-tolerant quantum computers. I am currently part of the executive leadership team of a major nationwide initiative with most prominent quantum computing actors, where I contribute to strategic research planning and interdisciplinary coordination.[1]

Beyond quantum information science, I also work on **inverse Markov field problems**, **high-dimensional probabilistic inference** and **state identification for energy networks**. A unifying theme across my research is leveraging statistical methods and computer science techniques to understand, optimize and control networked systems.

EDUCATION

PH.D. IN COMPUTER AND COMMUNICATION SCIENCES
Ecole Polytechnique Fédérale de Lausanne (EPFL)   📅 2014

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BACHELOR AND MASTER OF SCIENCE IN PHYSICS
Ecole Polytechnique Fédérale de Lausanne (EPFL)   📅 2008

ACADEMIC APPOINTMENTS

SCIENTIST III   **LOS ALAMOS NATIONAL LABORATORY**
📍 Los Alamos NM, USA   📅 August 2020 – Until Now

- Conducted research on quantum computing algorithms and state-identification for energy networks.
- Became part of the executive team of the US Quantum Benchmarking Initiative coordinating the efforts of around 50 scientists at LANL.
- Obtained $500K in competitive research grants.
- Supervised 2 PhD. student internships and 3 postdocs.
- Served on the grant reviewing committee for the Laboratory Directed Research and Development program in Quantum & Information Science.

SCIENTIST II   **LOS ALAMOS NATIONAL LABORATORY**
📍 Los Alamos NM, USA   📅 June 2016 – August 2020

- Conducted research on statistical learning of Markov random fields and probabilistic modeling for energy networks.
- Obtained $2.5M in competitive research grants.
- Supervised 7 PhD. student internships and 2 postdocs.

POSTDOCTORAL ASSOCIATE   **LOS ALAMOS NATIONAL LABORATORY**
📍 Los Alamos NM, USA   📅 June 2014 – June 2016

- Conducted research on optimization and control of energy networks.
- Supervised 1 PhD. student internship.

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[1] https://www.darpa.mil/research/programs/quantum-benchmarking-initiative

PUBLICATIONS

PEER-REVIEWED JOURNAL ARTICLES

1. **Cost of Emulating a Small Quantum Annealing Problem in the Circuit Model**
   J. Gonzalez-Conde, Z. Morrell, M. Vuffray, T. Albash, C. Coffrin, *Physical Review A*, 2025.
2. **Forced Oscillation Source Localization From Generator Measurements**
   M. Tyloo, M. Vuffray and A.Y. Lokhov, *EEE Transactions on Power Systems*, 2025.
3. **On the Emerging Potential of Quantum Annealing Hardware for Combinatorial Optimization**
   B. Tasseff, T. Albash, Z. Morrell, M. Vuffray, A.Y. Lokhov, S. Misra, C. Coffrin, *Journal of Heuristics*, 2024.
4. **Learning Energy-Based Representations of Quantum Many-Body States**
   A. Jayakumar, M. Vuffray, A.Y. Lokhov, *Physical Review Research*, 2024.
5. **Universal Framework for Simultaneous Tomography of Quantum States and SPAM Noise**
   A. Jayakumar, S. Chessa, C. Coffrin, A.Y. Lokhov, M. Vuffray, S. Misra, *Quantum*, 2024.
6. **Locating the Source of Forced Oscillations in Transmission Power Grids**
   R. Delabays, A.Y. Lokhov, M. Tyloo, M. Vuffray, *PRX Energy*, 2023.
7. **Signatures of Open and Noisy Quantum Systems in Single-Qubit Quantum Annealing**
   Z. Morrell, M. Vuffray, A.Y. Lokhov, A. Bärtschi, T. Albash, C. Coffrin, *Physical Review Applied*, 2023.
8. **Quantum Algorithm Implementations for Beginners**
   J. Abhijith, . . . , M. Vuffray, A.Y. Lokhov, *ACM Transactions on Quantum Computing*, 2022.
9. **Programmable Quantum Annealers as Noisy Gibbs Samplers**
   M. Vuffray, C. Coffrin, Y. Kharkov, C. Coffrin, *PRX Quantum*, 2022.
10. **High-Quality Thermal Gibbs Sampling with Quantum Annealing Hardware**
    J. Nelson, M. Vuffray, A. Lokhov, T. Albash, C. Coffrin, *Physical Review Applied*, 2022.
11. **Efficient Learning of Discrete Graphical Models**
    M. Vuffray, S. Misra, A. Lokhov, *Journal of statistical mechanics*, 2022.
12. **Single-Qubit Fidelity Assessment of Quantum Annealing Hardware**
    J. Nelson, M. Vuffray, A. Lokhov, C. Coffrin, *IEEE Transactions on Quantum Engineering*, 2021.
13. **The Impacts of Convex Piecewise Linear Cost Formulations on AC Optimal Power Flow**
    C. Coffrin, B. Knueven, J. Holzer, M. Vuffray, *Electric Power Systems Research*, 2021.
14. **The Potential of Quantum Annealing for Rapid Solution Structure Identification**
    Y. Pang, C. Coffrin, A. Lokhov and M. Vuffray, *Constraints*, 2021.
15. **Efficient Polynomial Chaos Expansion for Uncertainty Quantification in Power Systems**
    D. Métivier, M. Vuffray and S. Misra, *Electric Power Systems Research*, 2020.
16. **Monotonicity Properties of Physical Network Flows and Application to Robust Optimal Allocation**
    S. Misra, M. Vuffray and A. Zlotnik, *Proceedings of the IEEE*, 2020.
17. **Optimal Structure and Parameter Learning of Ising Models**
    A. Lokhov, M. Vuffray, S. Misra, M. Chertkov, *Science advances*, 2018.
18. **Graphical Models for Optimal Power Flow**
    D. Krishnamurthy, M. Chertkov, P. Van Hentenryck, M. Vuffray, S. Misra, *Constraints*, 2017.
19. **The Bethe Free Energy Allows to Compute the Conditional Entropy of Graphical Codes Instances: A Proof from the Polymer Expansion**
    N. Macris, M. Vuffray, *Information Theory, IEEE Transactions on*, 2016.
20. **Approaching the Rate-Distortion Limit with Spatial Coupling, Belief Propagation and Decimation**
    V. Aref, N. Macris, M. Vuffray, *Information Theory, IEEE Transactions on*, 2015.
21. **The Inviscid, Compressible and Rotational, 2D Isotropic Burgers and Pressureless Euler-Coriolis Fluids: Solvable Models with Illustrations**
    Ph. Choquard, M. Vuffray, *Physica D: Nonlinear Phenomena*, 2014.
22. **Bound States of the Schrödinger-Newton Model in Low Dimensions**
    J. Stubbe, M. Vuffray, *Nonlinear Analysis: Theory, Methods & Applications*, 2010.
23. **Stationary Solutions of the Schrödinger-Newton Model – An ODE Approach**
    Ph. Choquard, J. Stubbe, M. Vuffray, *Differential and Integral Equations*, 2008.

PEER-REVIEWED CONFERENCE PUBLICATIONS

1. **QuantumAnnealing: a Julia Package for Simulating Dynamics of Transverse Field Ising Models**
   Z. Morrell, M. Vuffray, S. Misra, C. Coffrin, *IEEE Int. Conference on Quantum Computing and Engineering (QCE)*, 2024.
2. **Single-qubit cross platform comparison of quantum computing hardware**
   A. Suau, J. Nelson, M. Vuffray, A.Y. Lokhov, L. Cincio, C. Coffrin, *IEEE Int. Conference on Quantum Computing and Engineering (QCE)*, 2023.
3. **Vector Field Visualization of Single-Qubit State Tomography**
   A. Suau, M. Vuffray, A.Y. Lokhov, L. Cincio, C. Coffrin, *IEEE Int. Conference on Quantum Computing and Engineering (QCE)*, 2022.
4. **Real-time Anomaly Detection and Classification in Streaming PMU Data**
   C. Hannon, D. Deka, D. Jin, M. Vuffray, A.Y. Lokhov, *IEEE Madrid PowerTech*, 2021.
5. **Exponential Reduction in Sample Complexity with Learning of Ising Model Dynamics**
   A. Dutt, A.Y. Lokhov, M. Vuffray, S. Misra, *Int. Conference on Machine Learning (PMLR)*, 2021.
6. **Learning of Discrete Graphical Models with Neural Networks**
   A. Jayakumar, A.Y. Lokhov, S. Misra, M. Vuffray, *Advances in Neural Information Processing Systems (NeurIPS)*, 2020.

7. **Efficient Learning of Discrete Graphical Models**
   M. Vuffray, A. Lokhov, S. Misra, *Advances in Neural Information Processing Systems (NeurIPS)*, 2020.
8. **Information Theoretic Optimal Learning of Gaussian Graphical Models**
   S. Misra, M. Vuffray, A.Y. Lokhov, *Conference on Learning Theory (COLT)*, 2020.
9. **Polynomial Chaos Approach to Describe the Propagation of Uncertainties Through Gas Networks**
   S. Gerster, M. Herty, M. Chertkov, M. Vuffray, A. Zlotnik, *Progress in Industrial Mathematics at ECMI*, 2019.
10. **Uncovering Power Transmission Dynamic Model from Incomplete PMU Observations**
   A.Y. Lokhov, D. Deka, M. Vuffray, M. Chertkov, *IEEE Conference on Decision and Control (CDC)*, 2018.
11. **Online Learning of Power Transmission Dynamics**
   A.Y. Lokhov, M. Vuffray; D. Shemetov, D. Deka, M. Chertkov, *Power Systems Computation Conference (PSCC)*, 2018.
12. **Fast and Robust Determination of Power System Emergency Control Actions**
   S. Misra, L. Roald, M. Vuffray, M. Chertkov, *Int. Institute for Research and Education in Power System Dynamics (IREP) conference*, 2017.
13. **Interaction Screening: Efficient and Sample-Optimal Learning of Ising Models**
   M. Vuffray, S. Misra, A. Lokhov, M. Chertkov, *Advances in Neural Information Processing Systems (NIPS)*, 2016.
14. **Monotone Order Properties for Control of Nonlinear Parabolic PDE on Graphs**
   S. Misra, M. Vuffray, A. Zlotnik, M. Chertkov, *Int. Symposium on Mathematical Theory of Networks and Systems (MTNS)*, 2016.
15. **Concentration to Zero Bit-Error Probability for Regular LDPC Codes on the Binary Symmetric Channel: Proof by Loop Calculus**
   M. Vuffray, T. Misiakiewicz, *Annual Allerton Conference on Communication, Control and Computing*, 2015.
16. **Monotonicity of Dissipative Flow Networks Renders Robust Maximum Profit Problem Tractable: General Analysis and Application to Natural Gas Flows**
   M. Vuffray, S. Misra, M. Chertkov, *Annual Conference on Decision and Control (CDC)*, 2015.
17. **Approaching the Rate-Distortion Limit by Spatial Coupling with Belief Propagation and Decimation**
   V. Aref, N. Macris, M. Vuffray, *Int. Symposium on Information Theory Proceedings (ISIT)*, 2013.
18. **Lossy Source Coding via Spatially Coupled LDGM Ensembles**
   V. Aref, N. Macris, R. Urbanke, M. Vuffray, *International Symposium on Information Theory Proceedings (ISIT)*, 2012.
19. **Beyond the Bethe Free Energy of LDPC Codes via Polymer Expansions**
   N. Macris, M. Vuffray, *Int. Symposium on Information Theory Proceedings (ISIT)*, 2012.
20. **Polymer Expansions for Cycle LDPC Codes**
   N. Macris, M. Vuffray, *Int. Zurich Seminar on Communications Proceedings (IZS)*, 2012.

BOOK CHAPTERS

1. **Quantum Annealing**
   C. Coffrin, M. Vuffray, in *Encyclopedia of Optimization*, Springer International Publishing, 2024.
2. **Graphical Models and Belief Propagation Hierarchy for Physics-Constrained Network Flows**
   M. Chertkov, S. Misra, M. Vuffray, D. Krishnamurthy, P. Van Hentenryck, in *Energy Markets and Responsive Grids. The IMA Volumes in Mathematics and its Applications*, Springer, 2018.

OTHER PUBLICATIONS

1. **Learning Response Functions of Analog Quantum Computers: Analysis of Neutral-Atom and Superconducting Platforms**
   C. Tüysüz, A. Jayakumar, C. Coffrin, M. Vuffray, A.Y. Lokhov, *arXiv preprint arXiv:2503.12520*, 2025.
2. **Potential Applications of Quantum Computing at Los Alamos National Laboratory**
   A. Bärtschi, F. Caravelli, C. Coffrin, J. Colina, S. Eidenbenz, A. Jayakumar, S. Lawrence, M. Lee, A.Y. Lokhov, A. Mishra, S. Misra, Z. Morrell, Z. Mughal, D. Neill, A. Piryatinski, A. Scheie, M. Vuffray, Y. Zhang, *arXiv preprint arXiv:2406.06625*, 2024.
3. **Discrete Distributions are Learnable from Metastable Samples**
   A. Jayakumar, A.Y. Lokhov, S. Misra, M. Vuffray, *arXiv preprint arXiv:2410.13800*, 2024.
4. **An Efficient Quantum Algorithm for Linear System Problem in Tensor Format**
   Z. Wu, S. Misra, T. Terlaky, X. Yang, M. Vuffray, *arXiv preprint arXiv:2403.19829*, 2024.
5. **Boundary-Induced Classical Generalized Gibbs Ensemble with Angular Momentum**
   F. Caravelli, M. Vuffray, *arXiv preprint arXiv:2407.08833*, 2024.
6. **Learning continuous exponential families beyond gaussian**
   C.X. Ren, S. Misra, M. Vuffray, A.Y. Lokhov, *arXiv preprint arXiv:2102.09198*, 2021.
7. **Fast and Robust Determination of Power System Emergency Control Actions**
   S. Misra, L. Roald, M. Vuffray, M. Chertkov, *arXiv preprint arXiv:1707.07105*, 2017.
8. **Monotone Order Properties for Control of Nonlinear Parabolic PDE on Graphs**
   S. Misra, M. Vuffray, A. Zlotnik, M. Chertkov, *arXiv preprint arXiv:1601.05102*, 2015.
9. **Natural Gas Flow Solutions with Guarantees: A Monotone Operator Theory Approach**
   K. Dvijotham, M. Vuffray, S. Misra, M. Chertkov, *arXiv preprint arXiv:1506.06075*, 2015.
10. **Maximum Throughput Problem in Dissipative Flow Networks with Application to Natural Gas Systems**
   S. Misra, M. Vuffray, M. Chertkov, *arXiv preprint arXiv:1504.02370*, 2015.
11. **The Cavity Method in Coding Theory**
   M. Vuffray, *Doctoral dissertation*, Ecole Polytechnique Fédérale de Lausanne, 2014.

AWARDS & GRANTS

1. **Principal Investigator, Los Alamos Laboratory Directed Research & Development**
   Postdoctoral Director's fund for Fault Identification and Inference in Complex Networked Systems, $350K, 2022 – 2024.
2. **Principal Investigator, Los Alamos Laboratory Directed Research & Development**
   Exploratory Research Seedling on Locating Forced Oscillations in Power Networks, $150K, 2022 – 2023.
3. **Principal Investigator, U.S. Department of Energy/Office of Electricity**
   Advanced Grid Modeling on AC-OPF under Uncertainty, $1.5M, 2017 – 2020.
4. **Co-Principal Investigator, Los Alamos Laboratory Directed Research & Development**
   Exploratory Research on Uncertainty Quantification and Optimization in Non-Linear Network Systems, $900K, 2017 – 2019.

AWARDS & HONORS

Los Alamos Award Program Award   2025

The award recognizes employees at the Los Alamos National Laboratory for exceptional performance and behaviors. In recognition for accomplishments made in the Theoretical Division to the Quantum Benchmarking Initiative Project.

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LANL Spot Award   2024

This award recognizes employees for their contributions and specific accomplishments at the Los Alamos National Laboratory. In recognition for coordinating DARPA oportunities and projects.

- -

LANL Small Team Distinguished Performance Award   2023

This award recognizes outstanding performance by small teams across all areas of the Los Alamos National Laboratory's mission, including science, engineering, and operations. In recognition for the contribution made to the US2QC project.

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LANL Spot Award   2017

This award recognizes employees for their contributions and specific accomplishments at the Los Alamos National Laboratory. In recognition for contributions made to safety and security.

- -

Best Paper Award   2016

For best paper submitted at the 2016 Constraint Programing conference, entitled "Graphical Models for Optimal Power Flow".

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Center for Nonlinear Studies Postdoctoral Fellowship   2014 — 2016

Competitive, merit-based grant, that provides 50% time of freedom for focusing on research and training. Granted by the Los Alamos National Laboratory.

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Award for Excellence in Physics   2003

Granted by the Jules Bezencenet fund in Switzerland for outstanding performances in physics in high-school.

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Award for Excellence in Mathematics   2003

Granted by the State Department of Education of Vaud, Switzerland, for outstanding performances in mathematics in high-school.

TEACHING EXPERIENCE

- **Teaching assistant and lead teaching assistant at the Ecole Polytechnique Fédérale de Lausanne (EPFL)**, 2007 — 2013.
  Assisting in the preparation, grading and leading the exercice sessions for 15 undergraduate and graduate courses in Mechanics, Thermodynamics, Electromagnetism, Real and Multivariate Analysis, Probability and Statistics, Cryptography, Error Correcting Codes, Information Theory and Quantum Information Theory.
- **Creation and Development of Visualis Physics**, 2003 — 2004.
  Visualis Physics is a suit of educational software offering clear and interactive views of many physical phenomena. The software is published on the Steam platform and is declined in two modules: Electromagnetism and Dynamics (`www.visualis-physics.com`).

JUNIOR RESEARCHER MENTORING

POSTDOCTORAL RESEARCH FELLOWS

1. **Minh Vu**, Los Alamos National Laboratory, 2023 — Until Now.
2. **Abhijith Jayakumar**, Los Alamos National Laboratory, 2022 — 2025.
3. **Melvyn Tyloo**, Los Alamos National Laboratory, 2022 — 2024.
4. **Forrest Sheldon**, Los Alamos National Laboratory, 2019 — 2021.
5. **David Métivier**, Los Alamos National Laboratory, 2019 — 2020.

PHD. STUDENT INTERNS

1. **Zeguan Wu**, Lehigh University, 2023 — Until Now.
2. **Abijith Jayakumar**, Indian Institute of Science, Summer 2020.
3. **Luo Zhaorui**, Lehigh University, University of Arizona Tucson, Summer 2019.
4. **Devendra Shelar**, Massachusetts Institute of Technology, Summer 2018.
5. **Arkopal Dutt**, Massachusetts Institute of Technology, Summer 2018.
6. **Rob Brekelmans**,University of Southern California, Summer 2018.
7. **Sinong Geng**, Princeton University, Summer 2018.
8. **Dmitry Shemetov**, University of California Davis, Summer 2017.
9. **Alaa Moussawi**, Rensselaer Polytechnic Institute, Summer 2017.
10. **Theodor Misiakiewicz**, Ecole Normale Supérieure, Summer 2015.

SERVICE TO THE PROFESSION

REVIEW PANELS

1. Grant reviewer for the **United States National Science Foundation**, 2025.
2. Grant reviewer for the **Los Alamos Laboratory Directed Research and Development Program**, 2023 – 2025.

REVIEWER FOR JOURNALS

Referee for Nature Communication, Science Advances, Conference on Artificial Intelligence (AAAI), International Conference on Machine Learning (ICML), Conference on Advances in Neural Information Processing Systems (NeurIPS), Annual Conference on Learning Theory (COLT), IEEE Transactions on Information Theory, IEEE International Symposium on Information Theory (ISIT), IEEE Conference on Decision and Control (CDC), IEEE Transactions on Communications (TCOM).

CONFERENCE ORGANIZATION

1. Conference co-organizer, **2nd Physics Informed Machine Learning**, Santa Fe NM, USA, 2018.
2. Conference co-organizer, **Optimization and Inference for Physical Flows on Networks**, Banff, Canada, 2017.
3. Sessions co-organizer, **Information Theory and Applications Workshop**, San Diego CA, USA, 2017.
4. Conference co-organizer, **Physics Informed Machine Learning**, Santa Fe NM, USA, 2016.

INVITED TALKS & KEYNOTES

1. **Information Theory and Applications Workshop**, San Diego CA, USA, 2024.
2. **CCS 2023, Recent Advances in Learning and Data-Driven Modeling of Complex Systems**, Salvador, Bahia, Brazil, 2023.
3. **INFORMS Annual Meeting**, Indianapolis IN, USA, 2022.
4. **Information Theory and Applications Workshop**, San Diego CA, USA, 2022.
5. **CCS 2021, Data-based Diagnosis of Networked Dynamical Systems**, Lyon, France, 2021.
6. **IMA workshop, Theory and Algorithms of Graph-based Learning**, Minneapolis MN, USA, 2020.
7. **Information Theory and Applications Workshop**, San Diego CA, USA, 2020.
8. **MIT Institute for Foundations of Data Science Workshop**, Cambridge, Massachusetts, 2019.
9. **Information Theory and Applications Workshop**, San Diego CA, USA, 2019.
10. **International Symposium on Mathematical Programming**, Bordeaux, France, 2018.
11. **Information Theory and Applications Workshop**, San Diego CA, USA, 2018.
12. **INFORMS Computing Society Conference**, Austin TX, USA, 2017.
13. **Grid Science Winter School & Conference**, Santa Fe NM, USA, 2017.
14. **28th European Control Conference on Operation Research**, Poznan, Poland, 2016.
15. **INFORMS International**, Waikoloa HI, USA, 2016.
16. **Information Theory and Applications Workshop**, San Diego CA, USA, 2016.
17. **Break and Beyond Detailed Balance Condition**, Kyoto, Japan, 2015.
18. **IEEE Conference on Decision and Control**, Osaka, Japan, 2015.
19. **International Symposium on Mathematical Programming**, Pittsburgh PA, USA, 2015.