FORREST WOLFGANG GLINES, PhD

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EXASCALE AND GPU ASTROPHYSICS SOFTWARE ENGINEER

A developer of physics research codes with nearly a **decade of experience crafting high performance scientific software for GPUs on large scale clusters**. I specialize in developing and optimizing **performance portable software** – software that is highly performant on both GPUs and CPUs from a variety of manufacturers. Currently at Los Alamos National Laboratory as a Metropolis Postdoctoral Fellow I am developing and running astrophysical simulations on Frontier, the world's first exascale supercomputer**.** These simulations are performed with the AthenaPK astrophysics code I co-developed and the Parthenon adaptive mesh refinement framework that I co-started. These projects use the **Kokkos** performance-portability library to target GPUs and CPUs.

GPU Programming – High Performance Computing – Performance Portability – Performance Optimization
Astrophysics – Physics Simulations – Turbulence – Computational Fluid Dynamics – Data Analysis
Collaborative Software Development – Version Control – Technical Communication
Kokkos – CUDA – OpenMP – MPI – Advanced C/C++ – FORTRAN – Python – CMake – Make – git

RELEVANT EXPERIENCE

Exascale Astrophysics Software Developer **September 2022 - Present**
Los Alamos National Laboratory, Los Alamos, NM
As a Metropolis Postdoctoral Fellow, I carry out and support GPU-enabled astrophysics simulations at LANL.

- Developing, running and analyzing exascale astrophysics simulations on Frontier using AthenaPK, which attained 89% scaling on Frontier.
- Analyzed and optimized AthenaPK's performance on Frontier and AMD GPUs using performance analysis tools including TAU, Omniperf, and HPCToolkit.
- Enabling simulations of planetary formation, astrophysical jets, and plasmas through contributions to AthenaPK and Parthenon through a variety of collaborations at LANL.
- Developing a Parthenon frontend for yt, a Python library for astrophysical simulation analysis.

Relativistic Fluid Dynamics on GPUs Developer **December 2018 - August 2022**
Sandia National Laboratories, Albuquerque, NM (Partly remote)
Led development of relativistic hydrodynamics methods for the terrestrial plasma physics code EMPIRE

- Developed a novel, more robust discontinuous-Galerkin finite element method for relativistic hydrodynamics.
- Implemented said method for GPUs and CPUs for the EMPIRE terrestrial plasma code using Kokkos.
- Explored performance of said method and differences in performance characteristics between GPUs and CPUs.

Performance-Portable Astrophysics Researcher **August 2016 - August 2022**
Michigan State University, East Lansing, MI
Developed, optimized, and ran astrophysics codes for GPUs and CPUs in preparation for exascale for my dissertation.

- Co-developed K-Athena, one of the first performance-portable magnetohydrodynamics codes using Kokkos, adapted from the CPU-only code Athena++, and which we used for simulations of magnetized turbulence.
- K-Athena outperformed other GPU codes by 20% and attained 76% scaling on the Summit Supercomputer.
- Analyzed K-Athena's performance on 10 GPU and CPU architectures via roofline models generated from a performance analysis tools including Intel VTune, Intel Advisor, LIKWID, nvprof, and Nsight Compute.
- Co-started Parthenon, an adaptive mesh refinement framework for exascale motivated by the success of K-Athena
- Developed an exascale-ready astrophysics simulations in AthenaPK built upon Parthenon.

- Taught parallel computing classes for computational scientists, including node parallelism with MPI, CPU parallelism with OpenMP, and GPU programming in C/C++ and FORTRAN with CUDA and Kokkos.

GPU Fluid Dynamics Programmer **December 2013 – May 2016**
Brigham Young University, Provo, UT
As an undergraduate student researcher, I developed an early GPU-capable magnetohydrodynamics code.
- Adapted a legacy FORTRAN code into a GPU-enabled magnetohydrodynamics code in C using CUDA and MPI.
- Attained 85% weak scaling on 600+ Tesla K20 GPUs on Indiana University's Big Red II supercomputer.

EDUCATION

Doctor of Philosophy in Astrophysics and Computational Science, Michigan State University
Dissertation: "Numerical Simulations of Plasmas in Galaxy Clusters" **August 2022**

Bachelors of Science in Physics and Applied Mathematics, Brigham Young University
(Minor in Computer Science)
Magna cum laude **May 2016**

AWARDS

Metropolis Postdoctoral Fellowship **2022**
Los Alamos National Laboratory
Postdoctoral Fellowship to enable cutting-edge research of computationally driven science.

INCITE 2023 Award **2022**
US Department of Energy Office of Science
"Feedback and energetics from magnetized AGN jets in galaxy groups and clusters"
630,000 node-hours on Frontier to simulate galaxy groups and clusters.

Blue Waters Graduate Fellowship **2019**
National Center for Supercomputing Applications
Graduate fellowship to support early career computational researchers on the Blue Water supercomputer, which I used to study astrophysical turbulence.

RELEVANT PUBLICATIONS

Glines, F.W., Beckwith, K.R.C., Braun, J.R., Cyr, E.C., Ober, C.C., Bettencourt, M., Cartwright, K.L., Conde, S., Miller, S.T., Roberds, N., Swan, M.S., and Pawlowski, R. "A Robust, Performance-Portable Discontinuous Galerkin Method for Relativistic Hydrodynamics" 2022, arxiv.

Grete, P., Dolence, J.C., Miller, J.M., Brown, J., Ryan, B., Gaspar, A., Glines, F.W., Swaminarayan, S., Lippuner, J., Solomon, C.J., Shipman, G., Junghans, C., Holladay, D., and Stone, J.M. "Parthenon -- a performance portable block-structured adaptive mesh refinement framework" 2022, International Journal of High Performance Computing Applications

Glines, F.W., Grete, P., O'Shea, B.W. "Magnetized Decaying Turbulence in the Weakly Compressible Taylor-Green Vortex," 2021, Phys. Rev. E 103, 043203.

Grete, P., Glines, F.W., and O'Shea, B.W. "K-Athena: A Performance Portable Structured Grid Finite Volume Magnetohydrodynamics Code," 2020, IEEE Transactions on Parallel and Distributed Systems 32, 85–97.

Glines, F.W., Anderson, M., and Neilsen, D. "Scalable Relativistic High-Resolution Shock-Capturing for Heterogeneous Computing," 2015, IEEE International Conference on Cluster Computing, pp. 611–618.