Charles Martin McGrath, Ph.D.

Computational Scientist | Physicist

Data Science ▪ Imaging ▪ GPU Computing ▪ Experimental R&D

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Profile

Computational scientist and physicist with 6+ years developing imaging algorithms, physics-based simulations, and scientific software. ETH Zurich Ph.D. and Stanford postdoctoral scholar combining quantitative data analysis, GPU computing, and hands-on experimental R&D. Leads projects from mathematical models and acquisition through tested open-source tools and experimental evaluation.

Technical Skills

Programming	Python, C/C++, Julia, MATLAB; NumPy, SciPy, pandas, Numba, CuPy GPU acceleration, multiprocessing, multithreading; CUDA development
Data analysis	Scientific data pipelines, experimental design, uncertainty propagation Regression, hypothesis testing, Bland–Altman agreement analysis
Imaging	MRI physics, acquisition, reconstruction; inverse problems, signal processing Segmentation, registration, denoising, quantitative image analysis OpenCV, scikit-image, SimpleITK/ITK, VTK, PyVista, ParaView, 3D Slicer CT/ultrasound data analysis; advanced CT, ultrasound, PET/SPECT physics
Computing	Numerical methods, ODE/PDE solvers, CFD (SimVascular), particle tracking HPC, Linux, Slurm, Docker, Apptainer; profiling and memory optimization
Experiments	SolidWorks, Fusion 360, Onshape; FDM/SLA printing, machining Sensor calibration, electronics assembly, bench instrumentation, flow phantoms
Software quality	Git, unit/integration/regression tests, CI/CD, package development Documentation, reproducible environments, cross-platform deployment

Research & Engineering Experience

Postdoctoral Scholar | Stanford University Aug 2025–present

Cardiac MRI Research Group

- **Lead development of 4DFlowP**, an end-to-end MRI pipeline linking acquisition, GPU image reconstruction, artifact correction, and numerical cardiovascular pressure estimation.
- Evaluate measurement bias against CFD reference data; design and build cardiovascular emulators and flow phantoms, integrating CAD, fabrication, sensors, and pressure/flow calibration.
- Develop GPU simulation and computational phantoms; co-supervise graduate students, collaborate across research groups, and contribute to grant proposals.

Postdoctoral Researcher | ETH Zurich Nov 2024–Jun 2025

Cardiovascular Magnetic Resonance Group

- Developed 3D flow imaging for a 0.6 T MRI prototype, tuning low-rank reconstruction for anatomical image quality and quantitative velocity accuracy.
- Compared measurements in six subjects with a reference MRI method, achieving **3.96 cm/s velocity RMSE**; published in *Magnetic Resonance in Medicine* (2025).

Research & Engineering Experience (continued)

Doctoral Researcher | ETH Zurich 2020–2024

Cardiovascular Magnetic Resonance Group

- Developed self-gated flow imaging and scanner software in Philips PPE/C++; **halved scan time relative to a two-acquisition reference method** by eliminating a separate reference acquisition.
- Used spectral analysis to identify **up to 50% systematic underestimation** of a turbulence-related velocity metric; proposed redesigned measurement waveforms for correction.
- Built first-principles signal-to-noise models to guide imaging-system and acquisition design, linking simulation with scanner experiments and quantitative analysis.

Selected Scientific Software

CMRSim | Physics Simulation Framework 2022–2025

- Co-developed a peer-reviewed Python/TensorFlow GPU framework coupling motion, fluid flow, and MRI physics. Simulated **approximately 1.5 million particles with seven velocity encodings in 29 minutes** on an NVIDIA Titan RTX.
- Validated against analytical solutions and experimental data; delivered automated tests, CI/CD, reproducible examples, and user documentation.

MRSimTracks | Computational Fluid Dynamics Tools 2025–present

- Authored a Python/Numba particle tracker for time-varying CFD meshes: Runge–Kutta integration, accelerated tetrahedral interpolation, and flow-aware boundary reseeding to maintain particle density.
- Combined multiprocessing with streamed output for memory-efficient large simulations; delivered tests, CI/CD, and documentation.

CMRSim-CUDA | GPU Simulation Engine 2024–present

- Developed a C++/CUDA MRI physics engine for particle-based spin and flow simulation, implementing numerical integration on the GPU.

CMRseq | Acquisition Design Toolkit 2022–present

Authored a reusable Python framework for waveform design with hierarchical data structures, scanner-format interoperability (Pulseq), automated testing, CI/CD, and documentation.

KomaMRI.jl | Community Simulation Platform Contributor

Contribute GPU particle-tracking simulation and higher-order magnetic-field support in Julia; collaborate with JuliaHealth maintainers on features and issue resolution.

Education

Dr.Sc., Biomedical Engineering | ETH Zurich 2020–2024

M.Sc., Biomedical Engineering | ETH Zurich 2018–2020

Medical Physics Track, **with distinction**.

BASc., Engineering Physics | University of British Columbia 2013–2018

Selected Recognition & Publications

ISMRM Magna Cum Laude Merit Award (top 15%), 2023;

Best Abstract, Advances in MR Flow workshop, 2024; MRI Together, 2022.

Peer-reviewed work in *Magnetic Resonance in Medicine*: CMRSim simulation framework (2024); referenceless 4D flow imaging (2025).