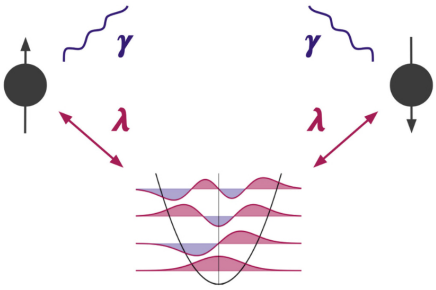
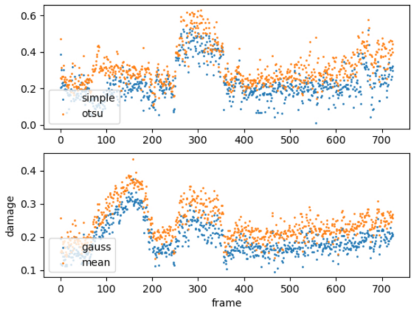
Research

Can we calculate quantum physics on quantum computers?

We already have quantum computers. They are far from perfect, but we decided to test them out. We used a physics model which itself can be used to describe some quantum computers. We further went beyond benchmarking current quantum computers, glimpsing into the future by simulating improved devices.

"Digital Quantum Simulation of the Spin-Boson Model under Markovian Open System Dynamics"
MDPI, Quantum Information
National University Singapore, Master thesis, 2022
Prof. Kwek Leong Chuan, Prof. Dario Poletti, Prof. Ulrich Schollwoeck





Can we automatically find damaged rails?

Historically rail inspection is done by professionals walking along the train tracks. We fixed a video camera on a metro train moving at 70km/h and let our code analyze the footage.

We used probabilistic hough transform and a decision tree to detect and cut out the rail in each frame. We than tested three variants of Canny edge detection and four variants of thresholds against a human expert in quantifying the damage.

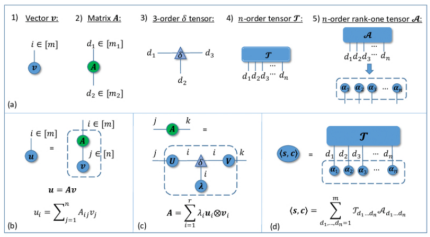
"Detection of rail surface irregularities using Edge Detection and Image Thresholding: a case study"
Iran University of Science and Technology, Internship, 2021
Prof. Morteza Bagheri, Dr. Sadegh Lajevardi

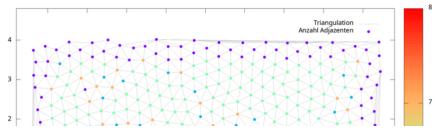
Can we calculate a bunch of quantum particles?

With many quantum particles together it's notoursly hard to predict how they will behave. There is one calculation often repeated (called SVD) and we found a way to speed it up big time.

I developed an algorithm to reorder sparse Tensors of abitrary rank to be block diagonal. The SVD is then performed on the individual blocks before recombining the results again. It's implemented for U(1) symmetric Tensors in the Tensor Network library "Syten".

"Block SVD (untitled)"
LMU Munich, HiWi, 2021
Prof. Ulrich Schollwoeck, Dr. Sebastian Paeckel

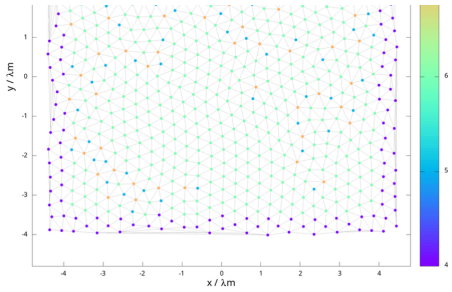




How can we make superconductors work?

Vorteces of magnetic flux can move around inside, making the superconductor useless. We are trying to hold the flux in place.

The forces governing the movement are mostly due to nearest



neighbours. I implemented a delaunay triangulation to find adjacent vorteces and calculated the forces in between them.

"Analyzing adjacent vorteces in a simulated type-II superconducter"
TU Wien, Bachelor Thesis, 2020
Prof. Franz Sauerzopf

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