Arbeits Tagebuch

Gian Laager

20.5.

- Started repo and setup C++ project

24.5.

- Initial research
- Found WKB Approximation Wikipedia

26.5.

- MIT lectures on WKB method and quantum mechanics

6.6.

- First test for serial and parallel integration.
- Major problems with multi threading
- Switched to Go programing language, implemented parallel integration and first WKB implementation according to Wikipedia

7.6.

- Fixed problem with bounds of integration and got good looking results
- Problems relating coefficients of oscillating and exponential part.

9.6.

- Attempt to implement caching system for integral after suggestion by Mr. Romer.
- Great performance and precision results when benchmarking

10.6

- fixed integral after debugging

12.6

- First implementation with Airy functions
- Assumption that Airy functions have to match exactly -> solve for constants with matrix
- Airy functions don't match nicely
- Implemented function for probability

14.6.

- Problems with Go because the code gets messy
- Complete rewrite in Rust

16.6.

- Attempt to implement Airy functions with Taylor series, not working
- Research Fourier transformation to implement Airy functions

19.6.

- Added Go library for Airy functions to Rust

29.6.

- Moved Airy functions to separate struct

2.7.

- Implementation of Newton's method for finding turning points
- Unit test for Newton's method
- Working Newton's method

3.7

- Build script for Go library
- Iterative Newton's method faster than recursive method
- Mathematical foundations for finding turning points and grouping
- Finding turning points with Newton's method

10.7.

- Code for two turning points
- Problems in the middle of the functions; phase wrong?
- Refactoring

15.6.

- Problem when one turning point boundary is outside the view
- Various methods to solve problem

17.7.

- Regula falsi for calculating turning points outside the view

20.7.

- Using actual energies
- Better results

2.8.

- Fixed issue in Airy functions

12.8.

- Start Probe Kapitel
- Newton's method

15.8.

- WKB approximation for Probe Kapitel

18.8.

- Integration for Probe Kapitel and correcting

11.9.

- Generalized Integration
- Switch from Wikipedia to Hall, better results.
- Still problems in the middle of the two osculating WKB parts.
- Attempt to fix with sign changes (not working)
- Invented system to generate "optimal" guess for Newton's method

20.9.

- Found parentheses error in phase
- Experimenting with various sign changes to fix problem at $x = 0$

25.9.

- Started algorithm to calculate energies
- Calculations to find solutions with integers

26.9.

- Decision use check periodically for discontinuities

28.9.

- Implementation to find energies for any potential
- Added automatic calculation for view
- Added automatic creation of WKB parts -> Possible to calculate potentials with more than two turning points

29.9.

- Changed energy form Hall to correct Sommerfeld condition
- Still problems in the middle of oscillating parts

1.10.

- Extended definition of Hall to complex solutions
- Reworked memory model of phase to Arc.

4.10.

- Research on joints for functions
- Hall example does not work

6.10

- First implementation of WaveFunctionBuilder
- Experiments with different architectures.
- Developed own methods for joints with $\sin^2()$ and $\cos^2()$

8.10.

- Implementation of exact solution in WolframScript
- Results strangely diverge and don't have the spirals observed in schroedinger$_{\text{approx}}$'s solutions -> Super Position?

9.10.

- Thought: Neural network back propagation for minimal error in Wolfram solutions, my neuronal network library?
- Mathematics to fix problem in the middle of oscillating parts:
  - choose between 4 operations: +, -, conj, -conj.
  - minimal error will be used
- One of these ops will be used on each function.
- Reworked structure of wave function builder

10.10.

- with$_{\text{op}}$ implementation, added "operations" to each wave function part, each of them gets rotate such that theres a minimal error both in the derivative and the actual value.
- Works for square potential
- Added joints between WKB parts, results look better.
- Operations don't influence probability, but joints do create an error.
- Replaced messy main function with wave function builder
- fixed error in Joints
- Added Super Position of multiple energies
- Results look very strange but may be correct
- fixed boundary issue with 10th energy of x^2
- added different scaling types
- save time by exiting find$\backslash_{\text{zeros}}$ when proposed guess is the same

12.10.

- Invested system to find optimal delta, to fix issue in the middle of oscillating WKB parts

13.10.

- Added joints between WKB functions
- Added plotting wave function parts separately
- Fixed joints between WKB functions because joint was not favored over Airy or WKB part
- Added plots module for a clear API in the main function
- Improved phase offset calculation

14.10.

- Wrote transition regions section
- Energy levels, compared exact values from WolframScript with approximate values

16.10.

- Finished energy levels and changed derivative implementation to Boost variant

18.10.

- Started turning points section

22.10.

- Finished turning points
- Started newtons rating function

24.10.

- Improved rating function and correct mathematical definition
- Wrote Vorwort and Many Worlds interpretation
- Researched original paper of Many Worlds to cite
- Researched original Schrödingers cat article

Vacation

31.10.

- Rewrite of Validity
- Reviewed lecture by Zwiebach

1.11.

- Added code as a symlink
- Started section Wave Function

3.11.

- Improved calculation of phase offset
- Finished wave function and superposition
- Started program manual, documenting the process of using the program

7.11.

- Research for "matching condition", found notes of Robert G. Littlejohn, not exact same notation
- Fixed problem of none matching osculating parts after suggestion by Mr. Romer.

- Compared the new method and the old one, new is better but has problems at the right turning points
- BETA TEST CODE LOCK, started release in git
- up until now I changed to code while I was working on the paper which meant I sometimes had to rewrite entire sections because of changes in the code

9.11.

- Changed view to match the paper
- refactoring

11.11.

- Specified Goals more precicely
- Updated integral for the new code

12.11.

- Finally fixed energy calculation because of a missing * 2, even though I knew something was wrong with the energies it took me 2 months until I noticed the arithmetic mistake.
- Changed graphics to correct energy levels

13.11.

- Finished updating all the plots to the correct energy calculations
- Added implementation to approximation scheme
- Added wave function parts
- Checked assembly of branching with constants in Rust, to ensure no performance penalty because of an option
- Added section PureWKB

- Reformatted lstlistings
- improved $\text{get}_{\text{expsign}}$
- refactoring
- designed graphics for "Reading Complex Plots" with p5js

14.11.

- Corrected Vorwort
- Wrote Results section and piloted examples
- updated code of appendix to latest commit

15.11.

- fixed view, now works as described in the paper
- Calculating energies of super positions in parallel after test on Robotiks server where not the full CPU could be utilized
- Send first version of Methods chapter to Christopher Golling for corrections and tips

17.11.

- Corrected methods chapter according to Christopher
- Started VMs for installation instructions on Arch, Ubuntu and Windows
- Installation was easy on Arch and Ubuntu but I ran into a linking error on Windows
- Reset my old MacBook for instructions on macOS

18.11.

- Reworked Windows instructions for WSL because of unresolvable linking errors of the Go library
- Moved installation section of Gnuplot to the respective OS
- Moved installation instructions for Rust to the respective OS
- Added Newton's method division by zero check
- Removed unused dependencies

19.11.

- Revised Preliminaries
- Added more wave functions to Results
- Corrected spelling mistakes in the code

21.11.

- Added benchmarks, some of them took hours to complete so I ran it over night

22.11.

- Corrected mistakes in the benchmarks and tested both on Robotiks server and laptop over night

23.11.

- Revised Methods chapter
- Analyzed benchmarks, and minor tested renormalization and energy searching more closely

26.11.

- added benchmarks to paper
- Improved exact.wsl script and compared results with approximations
- written conclusion
- added LGPL-3 licence to code
- refactoring
- first draft

28.11.

- improvements of Methods chapter

29.11.

- Checking character limit, I had to remove a lot of the code because I initially had 100'000 characters
- Still 62'000 characters without code
- First draft of Abstract, searching for good plot for "Visualisierung".

30.11.

- Send version to Abigail to correct the language
- Moved manual to appendix after discussion with Mr. Romer

1.12.

- Reading through the work my self chapter by chapter and correcting as I go along
- Moved section Turning Points before Approximation Scheme because turning points are necessary for the approximation
- Revised calculation chapter

- Fixed mistake in color plots where the order of the arguments in atan2 was wrong
- Replotting affected plots
- Revised calculations according to Christopher

2.12.

- Received corrections from Abigail
- Fixing language for the rest of the evening

3.12.

- Replotting some graphs because axis labels were missing
- Correcting Abstract
- Amend this document
- Digging deep into the abstract mathematical ideas of modern quantum mechanics (Youtube: XylyXyly, QED Prerequisite Topics)
  - "Understanding" interesting correspondences between Hilbert space and space time described by Stephen Wolfram's hypergraph theory
  - Question: Are wave functions with different energies orthogonal in Hilbert space?

4.12.

- Last edits

5.12.

- Print

Self Reflection on the Working Process

I think my working process was quite good. But one of the problems was that I focused to much on the formalism presented in Wikipedia, to be fair the same equations were also used in the Lectures of Zwiebach. Once I switched to Hall the results became much better. Also it was good that I tried multiple programing languages, helped me find the right tool. Even though I had to debug for hours and tried various mathematical models I think it would have been better if I had a look at the actual solutions rather then guessing the properties that the wave function should have; this was why I insisted on the spiral for so long. Initially I tried to write unit test but this was very difficult because I did not know how the solutions should look like.

I didn't enjoy writing the paper which meant I frequently tried something new in the program, which meant the sections I had already written in the paper were outdated. In the end I had to force my self to stop working on the code and actually finish the paper itself.