Modeling the inductively shunted Cooper pair box: halfway report

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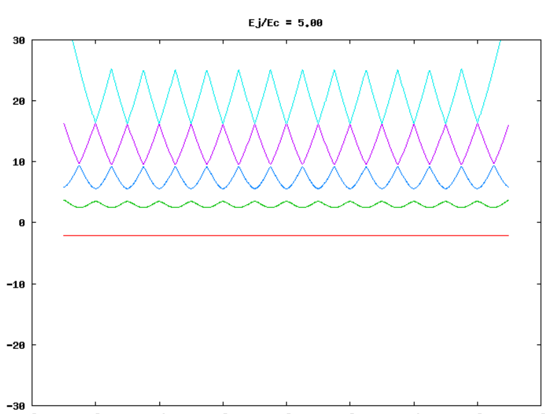
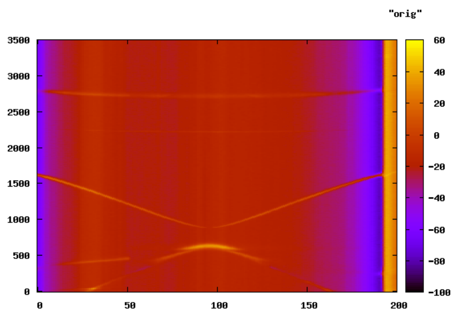
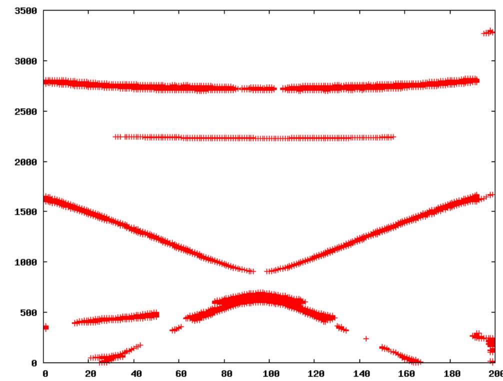
The Cooper pair box is a well-studied quantum circuit that can be studied as an artificial atom. The inductively-shunted Cooper pair box (LCPB) is much less well-studied. Adding an inductive shunt promises to reduce ambient charge noise around the circuit, but it also produces a Hamiltonian with completely different characteristics. The first examples of these circuits are being studied in by Vlad Manucharyan in one of the labs in Becton. Computer models of the Hamiltonian for these circuits exist, but they are too slow to be helpful in interpreting the experimental data. We hope to build a more efficient model and tools that can automatically filter those data and fit the results.

During the first semester most of my work was geared towards learning the physics and mathematics involved. We put together two working models, one of a simpler potential and one of the unmodified Cooper pair box. I used the latter to produce the energy graphs I showed in my presentation. We also coded a filter to pull relevant curves out of our experimental data.







In the second semester, the main focus will be on adapting the previous semester's work to the LCPB. Once that is working, the biggest challenge will be to put together automatic curve fitting for the experimental data. That will be the point where the inefficiencies of our model begin to show. Once everything is working, we should be able to get a better handle on our existing experimental data and guide the experiments into new parameter regimes.

All of the work so far has been done in the Python programming language, using a library called SciPy for the higher mathematics (Hermite polynomials and linear algebra). Python is an excellent environment for prototyping, but one possibility moving forwards, after we finish the first version of our final product, will be to look for less convenient but more efficient alternatives. One of the biggest factors slowing down existing models in Mathematica is arithmetic performed on extremely large and extremely small floating point numbers. Coding the bignum arithmetic "by hand" might give us more flexibility to make approximations, if we ultimately have enough time to implement that.