EFM With Field in 100 Starting With Random and Ground Initial States

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Overview

The effective field method was used to 3000 iterations to determine the 0 temperature states of the 12x12x12 3D FCC kagome lattice while being subjected to a changing magnetic field along the 100 direction. The field was either incremented or decremented in steps of 0.0001. There were 4 cases studied:

1. **Increasing** magnetic field in the **100** direction from **0.00 to 0.05**, with an initial spin configuration that was a **ground state** with theta = 0.206275 and phi = 3.11867.
2. **Increasing** magnetic field in the **100** direction from **0.00 to 0.05**, with an initial spin configuration that was **randomly generated**.
3. **Decreasing** magnetic field in the **100** direction from **0.05 to 0.00**, with an initial spin configuration that was a **ground state** with theta = 0.206275 and phi = 3.11867.
4. **Decreasing** magnetic field in the **100** direction from **0.05 to 0.00**, with an initial spin configuration that was **randomly generated**.

Analysis that was performed on the resulting data included the following:

- Plots of magnetization versus field
- Plots of energy versus field
- Animations of the characteristic 6 spins
- Determination of the number of "unique" spins that populate the lattice
- Determination of the components of the unique spins
- Dot products of each of the 6 spins with their respective "*neighbors*".

RUN 1: Increasing Field, Ground State

Two inflection points are observed in the magnetization graph. There are two inflection points in the energy graph as well, however they are not as obvious. A planar state is achieved at 0.0041. Between 0.0041 and 0.0064, the brown and green spins become closer to one another, as do the red and purple spins. The pink and blue spins remain fixed. The spins gradually align with the field, until it suddenly snaps into its final position where the blue and pink spins point in the same direction, in addition to lying within the xy plane.

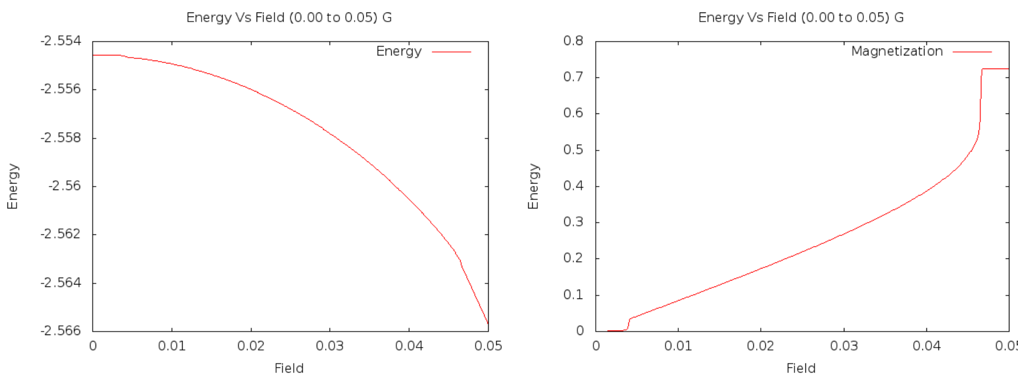


Figure 1: Energy vs increasing field and Magnetization versus increasing field

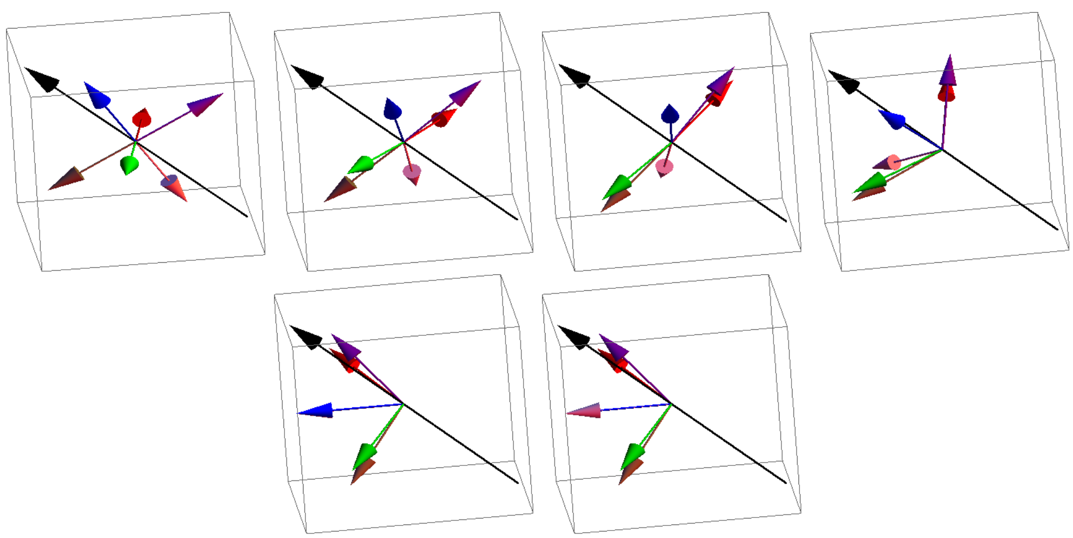


Figure 2: H=0, 0.0041, 0.0064, 0.0455, 0.0471, and 0.05

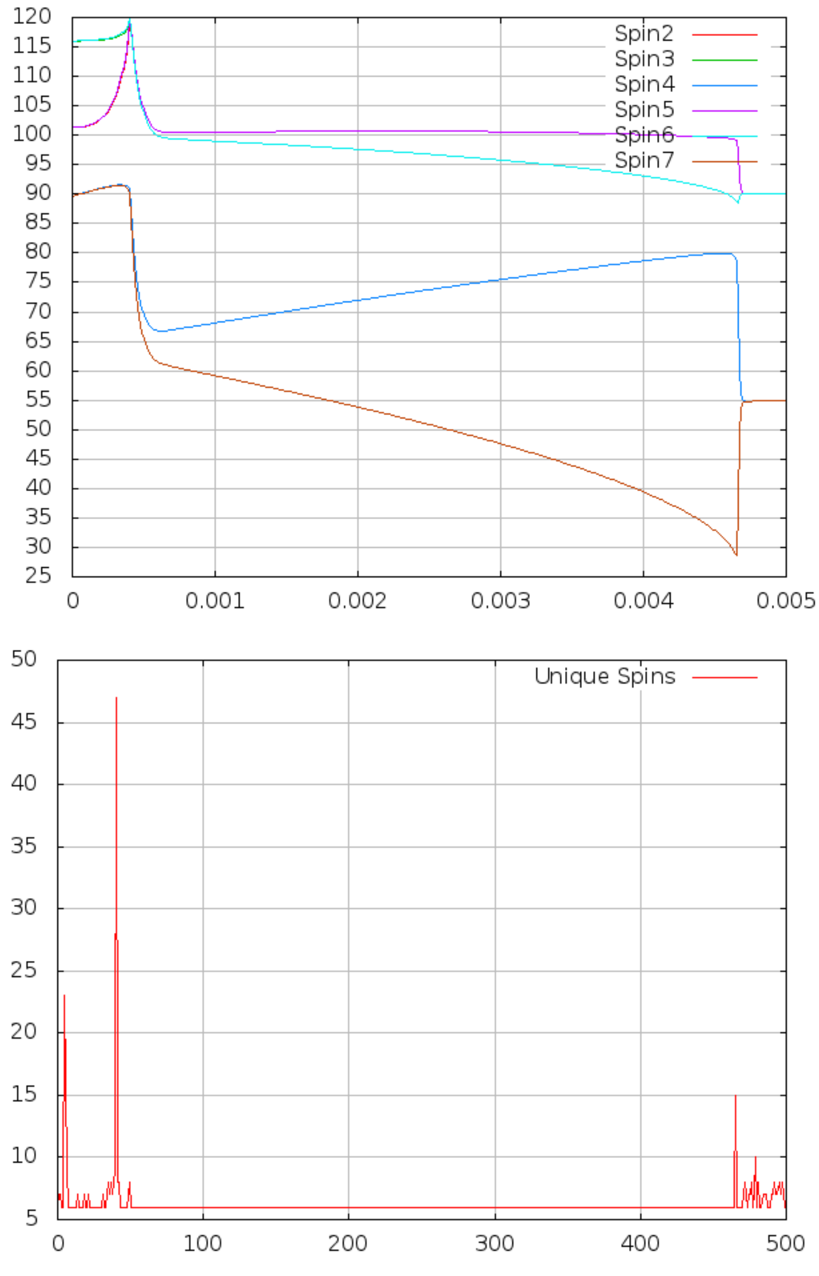


Figure 3: Dot products of each spin with its "*neighbour*′′. The number of unique spins within the lattice is also present.

RUN 2: Decreasing Field, Ground State

The initial configuration of the lattice is the same configuration as the final configuration when increasing the field. See Run 1. As the field is decreased, the spins are released from the nonplanar state, and return to the typically observed planar state, that gradually unaligns with the field direction as the field is decreased. Finally, the spins return to a full planar state.

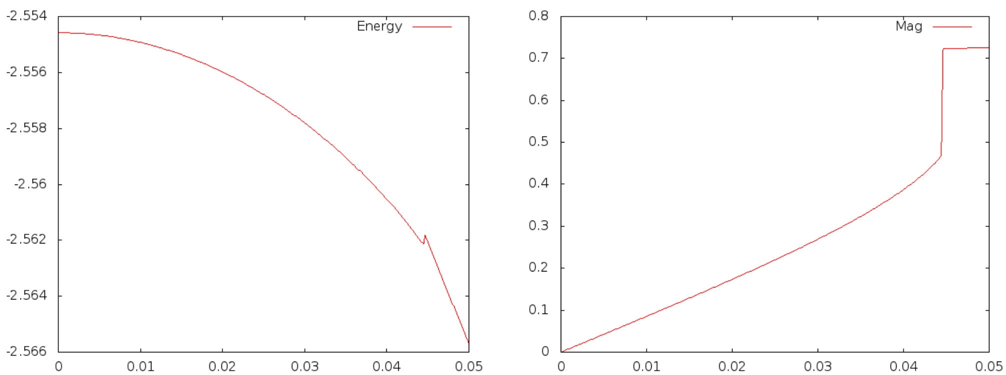


Figure 4: Energy vs decreasing field and Magnetization versus decreasing field

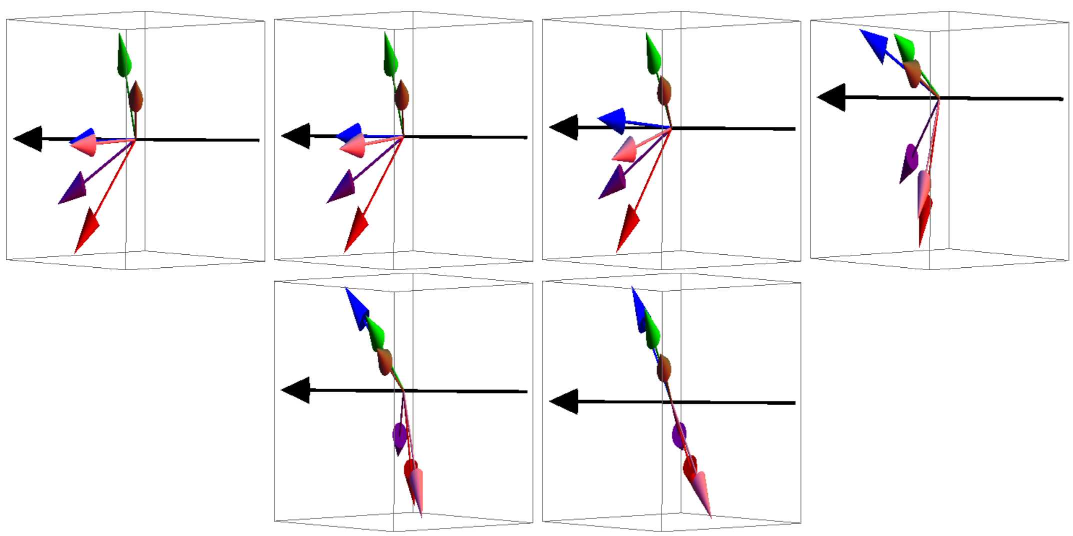


Figure 5: H=0.05, 0.0447, 0.0446, 0.0445, 0.0244, and 0

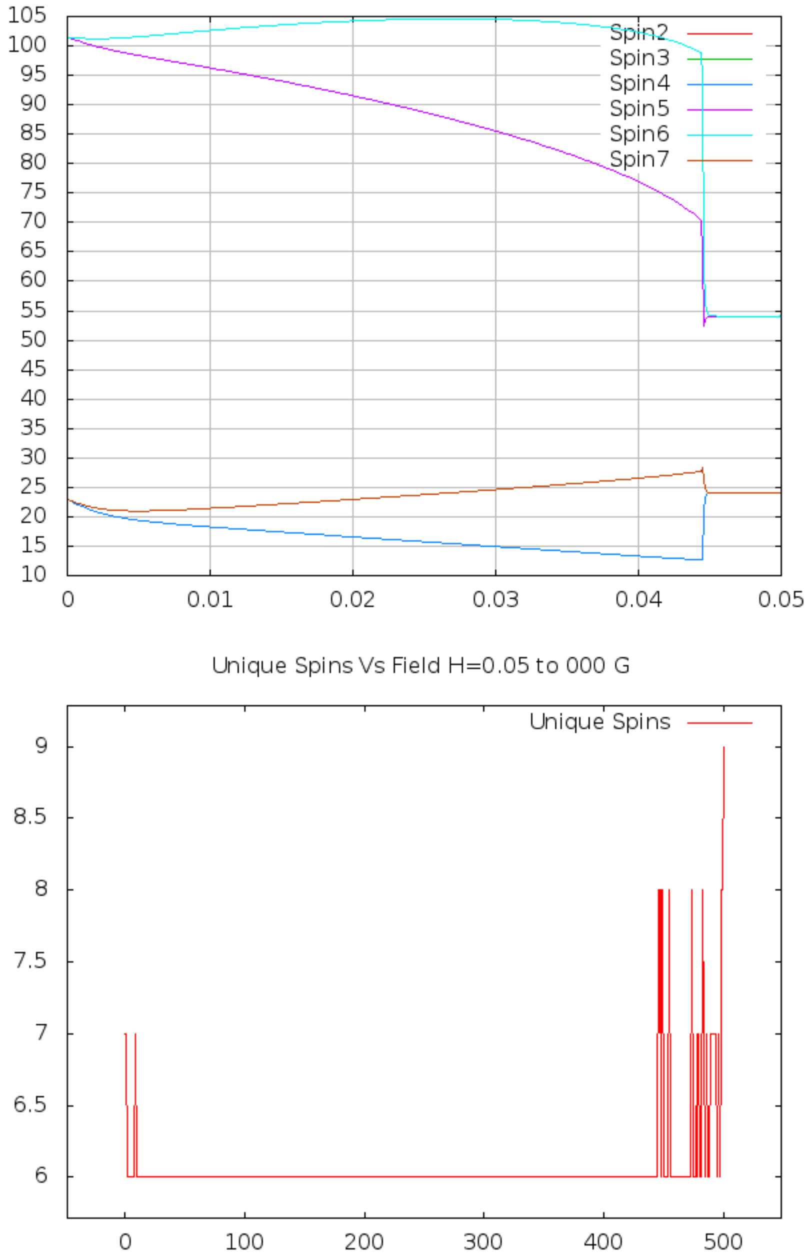


Figure 6: Dot products of each spin with its neighbours. The X-axis has been incorrectly factored by 1/10 in the dot product graph. The number of unique spins within the lattice is also present.

RUN 3: Increasing Field, Random State

The energy drops very quickly at near zero field, which is likely because of insufficient number of iterations. Two points of inflection are observed, as in Run 1. The transition of the spins is very similar to starting from a ground state.

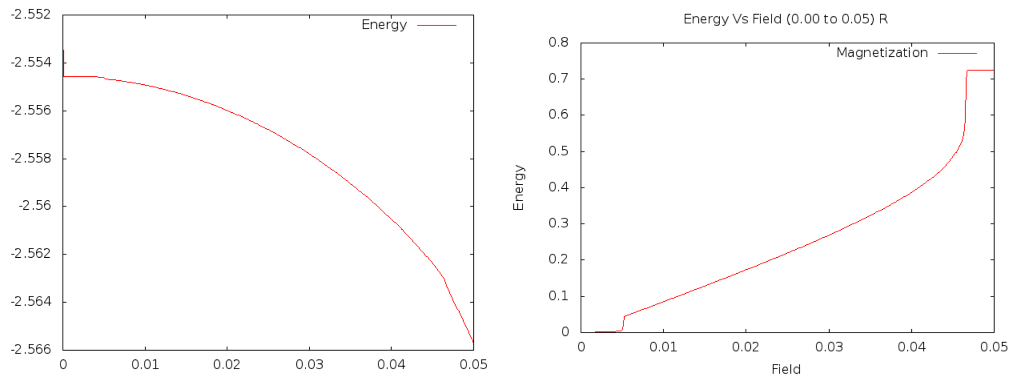


Figure 7: Energy vs increasing field and Magnetization versus increasing field

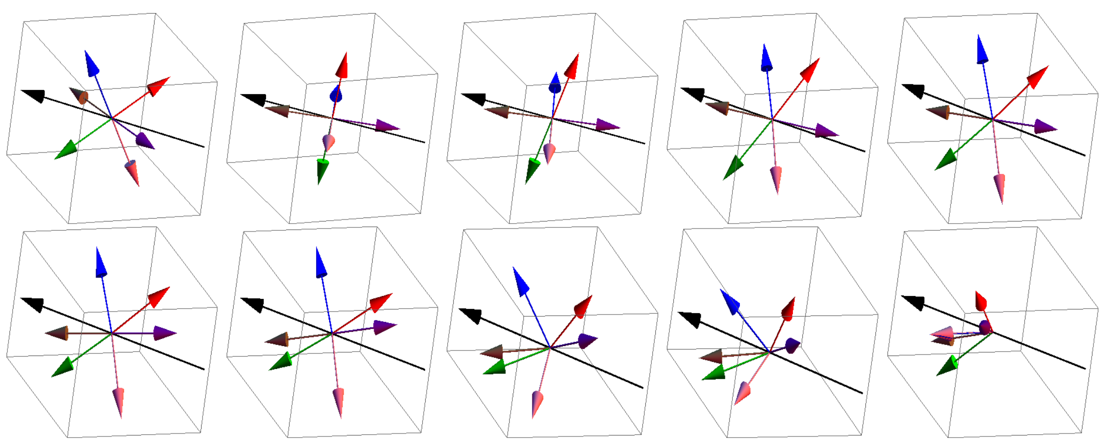


Figure 8: H = 0.00, 0.0002, 0.0047, 0.0052, 0.0054, 0.0057, 0.067, 0.0430, 0.0466, 0.05

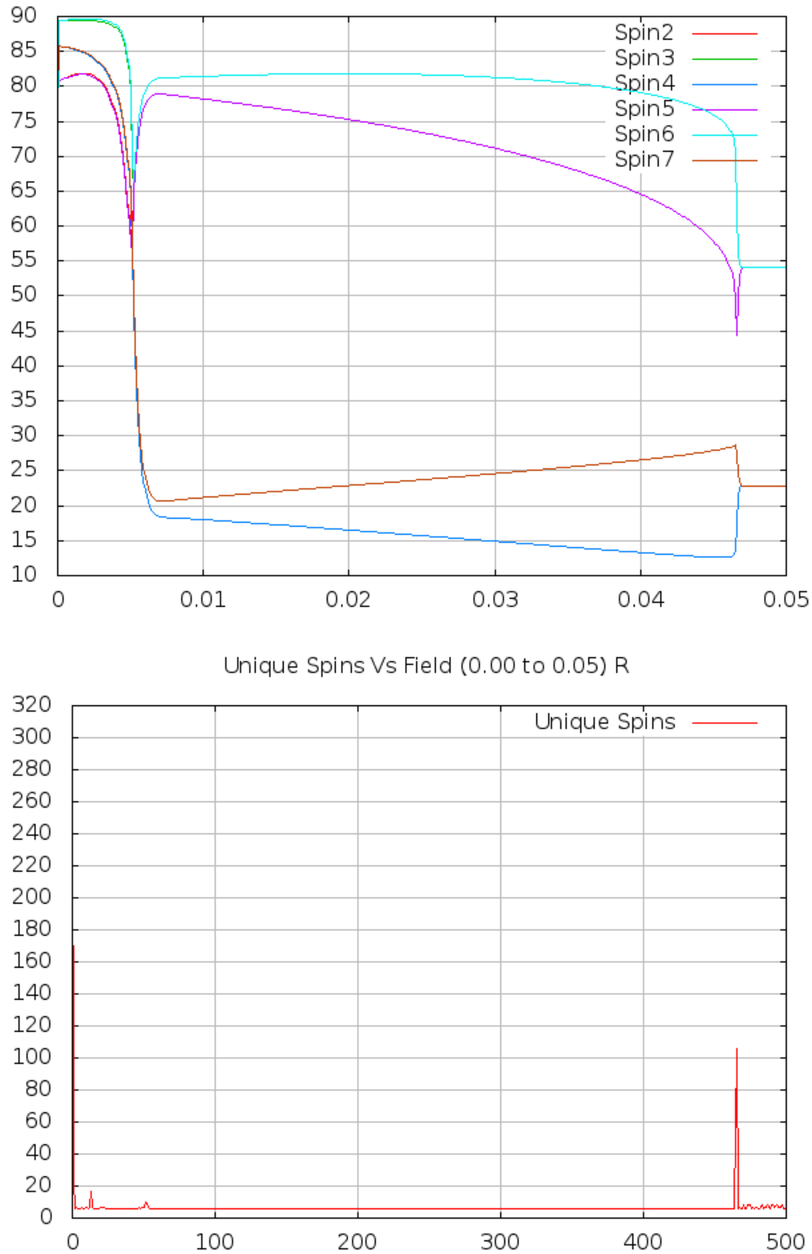


Figure 9: Dot products of each spin with its “neighbour”. The X-axis has been incorrectly factored by 1/10in the dot product graph. The number of unique spins within the lattice is also present.

RUN 4: Decreasing Field, Random State

The lattice starts off in a planar state. As the field is decreased, spins gradually unalign with the field. Suddenly, at 0.0455, the spins snap back into a slight realigned planar state. Another sudden readjustment is observed at 0.025. Finally, the spins return a full planar state at 0 field. The red and brown spins swap positions as the field lowers, as do the green and purple spins.

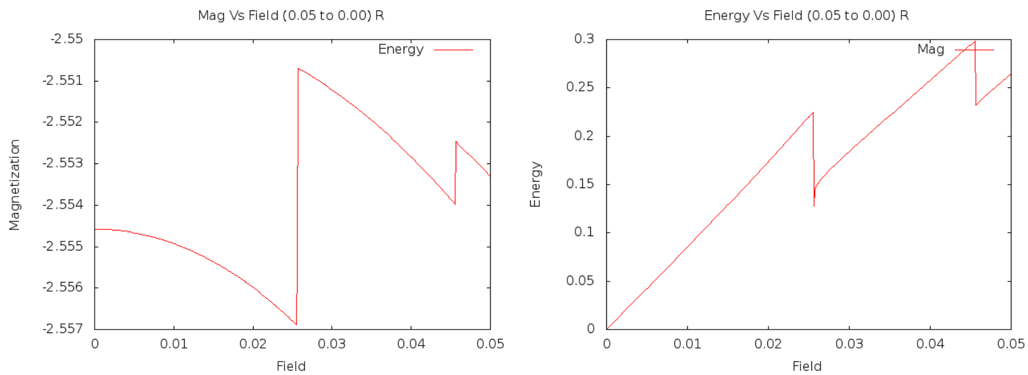


Figure 10: Energy vs decreasing field and Magnetization versus decreasing field

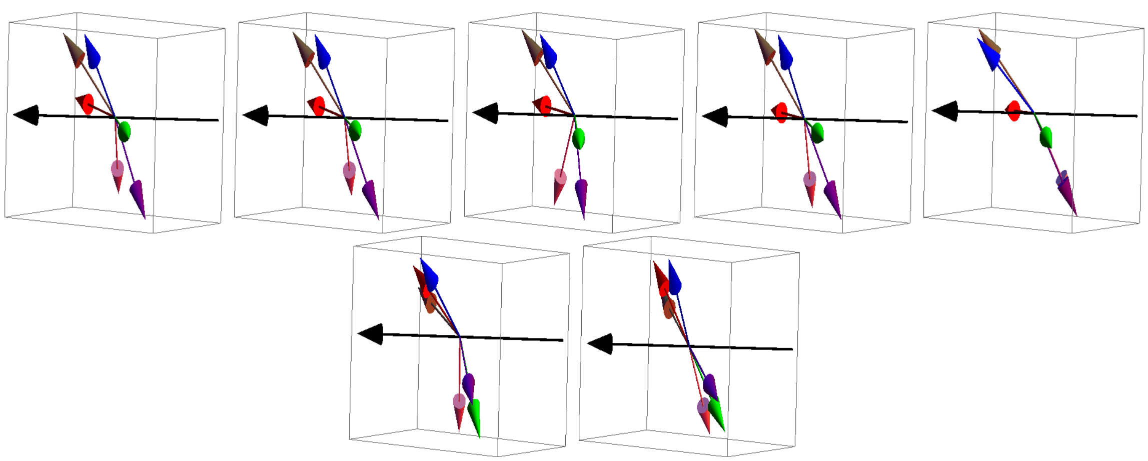
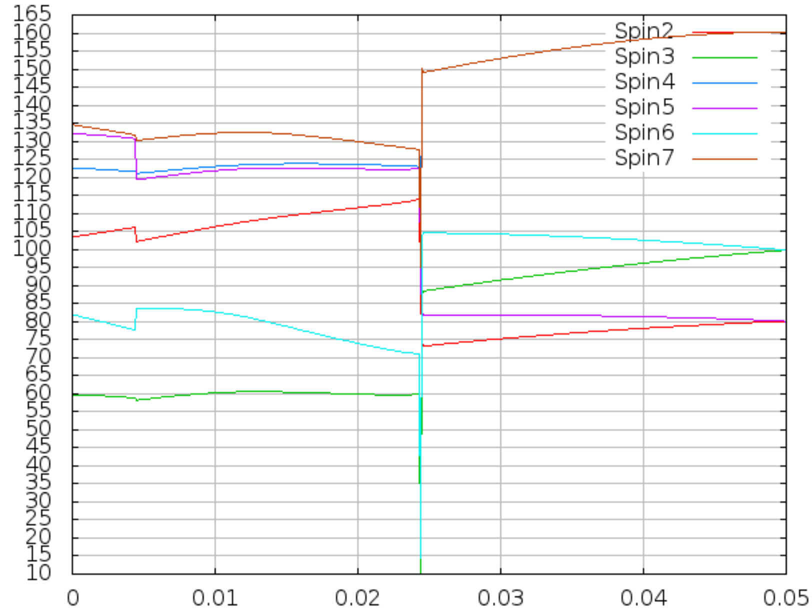


Figure 11: H = 0.05, 0.0457, 0.0455, 0.0258, 0.0256, 0.0255, 0.00.



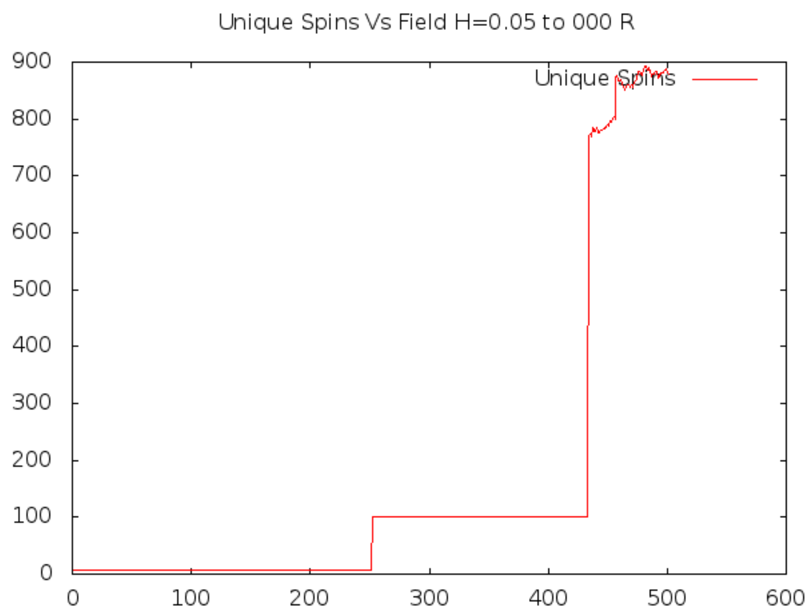


Figure 12: At high field, a huge number of “*unique*″ spins was observed. When looking through one of the configuration files, most spins only agreed with some other spins to at most 1 decimal place. The program that determines whether a spin is unique considers a spin to be unique when it agrees with a previously found spin up to at least two decimal places. Hence, the large number of unique spins present.The plateau in the middle is actually just false data I put into the text file, since I cancelled the program since it was taking a very long time. I reran the program from around H = 0.0250 to 0, and found that the lattice in this field range always had 6 unique spins.