Diffusion Constant of 3D Random Walk

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I. INTRODUCTION

Many real life systems include behavior that is random or unpredictable. One of the ways that effectively handles modeling these types of systems is the random walk method. A random walk is where a particle is said to move in a randomly determined direction of unity length, or of random lenth[1]. This work will examine a random walk in three dimensional space and determine the diffusion coefficient.

II. DIFFUSION COEFFICIENT

Because of the random nature of the walk and change position, the $< x_n >$ will always be zero. Something that is more indicative of describing the system is examining what happens to $< x_n^2 >$. This quantity changes in a way that is proportional to the time elapsed and the diffusion constant in a linear fashion[1].

$$< x_n^2 >= Dt \tag{1}$$

III. METHOD

This worked examined one random walker and its path, taking the average of all prior values of r^2. The random direction of the walk was determined by generation three random numbers. An x, y, and z value that were then turned into a displacement unit vector and added to the previous position.

IV. RESULTS

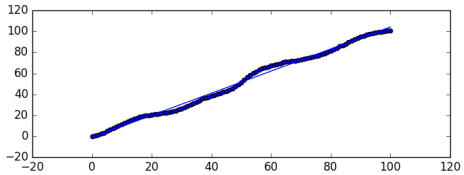

FIG. 1: cross section of the electric potential field

V. CONCLUSION

As figure 1 demonstrates, the $< x^2 >$ value of the system does change at a rate roughly equal to Dt. For this system the diffusion coefficient was found to be 1.05. Something for further consideration would be examing what happens with multiple walkers. When more walkers are added to the system the linear nature of the change in $< x^2 >$ over time would become more pronounced.

Bibliography

[1] N. J. Giordano and H. Nakanishi, *Computational physics* (Pearson Education India, 2006).