



Stochastic space interval as a link between quantum randomness and macroscopic randomness?[☆]

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HIGHLIGHTS

- Quantum Randomness and Macroscopic Randomness.
- Random behavior in trillions of photons.
- Stochastic Space Interval as possible explanation for fat-tailed distributions.
- Can quantum randomness explain fat-tailed distributions in finance?

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ABSTRACT

For many stochastic phenomena, we observe statistical distributions that have fat-tails and high-peaks compared to the Gaussian distribution. In this paper, we will explain how observable statistical distributions in the macroscopic world could be related to the randomness in the subatomic world. We show that fat-tailed (leptokurtic) phenomena in our everyday macroscopic world are ultimately rooted in Gaussian – or very close to Gaussian-distributed subatomic particle randomness, but they are not, in a strict sense, Gaussian distributions.

By running a truly random experiment over a three and a half-year period, we observed a type of random behavior in trillions of photons. Combining our results with simple logic, we find that fat-tailed and high-peaked statistical distributions are exactly what we would expect to observe if the subatomic world is quantized and not continuously divisible. We extend our analysis to the fact that one typically observes fat-tails and high-peaks relative to the Gaussian distribution in stocks and commodity prices and many aspects of the natural world; these instances are all observable and documentable macro phenomena that strongly suggest that the ultimate building blocks of nature are discrete (e.g. they appear in quanta).

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[☆] An early working paper version of this work appeared in Haug's self-published "working paper book" – "New Fundamental Physics". This early working paper version had several errors and did not have the complete photon series from the full experimental study. There were also some logical flaws in the discussion. This final version has been significantly improved and peer-reviewed. We would like to thank two anonymous referees for very useful comments as well as a thank you to Victoria Terces for great help with editing. Any remaining errors are our responsibility.

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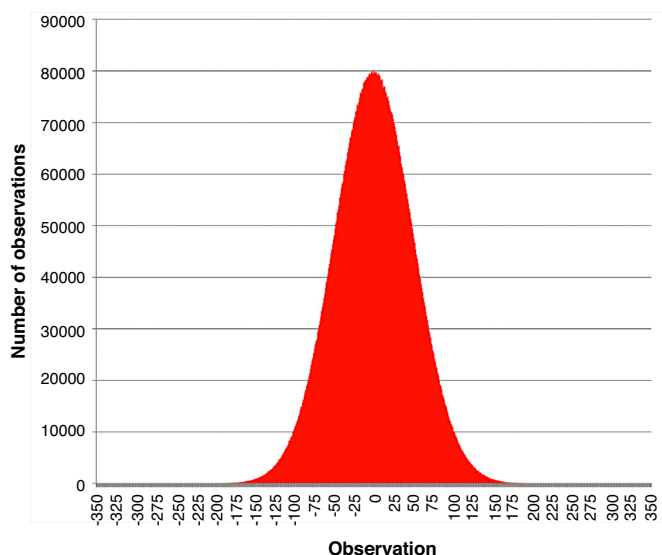


Fig. 1. Illustration of the typical Gaussian distribution, also known as the normal distribution.

1. Introduction

We focus on understanding the fat-tailed and high-peaked statistical distributions that we observe around us from the point of view of fundamental physics. In this exploration, we assess not only distinct physical events, but also phenomenon related to human behavior. Is this even possible? Remarkably, the answer is yes. We assume everything that can be observed ultimately consists of discrete subatomic particles. If we understand the randomness affecting each particle, then we should be able to evaluate the uncertainty around macroscopic phenomena more clearly by viewing them as the aggregate of a massive number of subatomic particles.

In the experiment we use only one type of “particle”—photons. An interesting question is: if we were using a different type of quantum particle, electrons, for example, would that give us different results? Based on the argumentation that is presented in the paper, we think that using a different type of particle would not be likely to change the main conclusions of the paper. It is also not that important what these particles actually are; the critical point is that the ultimate building blocks of nature are quantized. Further, a long series of experiments indicates that the subatomic world is indeed quantized, even though there are various interpretations of this concept and its implications.

2. The Gaussian curve and its failure

The normal distribution, also known as the “bell curve” or the “Gaussian distribution”, is a cornerstone of modern statistics, and is actively used (and sometimes abused) across many scientific fields and social sciences, including physics, cosmology, biology, medicine, mathematical finance, and macroeconomics. Many scientists assume that the Gaussian distribution is a good description of the statistical distribution of many random phenomena. Specifically, the Gaussian curve provides information about data points that are random or at least appear to be random and describes how the phenomena in question are statistically distributed (clustered) relative to the mean. Fig. 1 shows a typical Gaussian distribution.

In order to draw the theoretical Gaussian curve for a particular phenomenon, one simply needs the mean and the standard deviation. Based on this information, one can accurately describe the entire statistical distribution of the phenomenon. Naturally this only holds true if the real distribution is normally distributed in reality.

2.1. A short history of the Gaussian curve

What is today known as the normal distribution was first described in 1733 by the French mathematician, Abraham de Moivre (1667–1754), although his theory would soon be partly forgotten. The French mathematician, Pierre-Simon Laplace (1749–1827), published a similar theory, and in many ways, extended de Moivre’s result in his 1783 publication, and also in his book entitled, *Analytical Theory of Probabilities* (1812). Today, the credit for describing the normal distribution in detail often goes to the famous German mathematician, Carl Friedrich Gauss (1777–1855), even though Laplace was years ahead of him in describing such a statistical distribution. Gauss supposedly claimed that he had used the normal distribution since 1794, but he first explained it in written form in 1809. The French mathematician and artillery officer, Esprit Jouffret (1837–1904), was probably the first to use the term *bell curve* in 1872. He ascribed this name to the curve because the normal

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