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Introduction to Brownian Motion in Class XII Senior High School 5 Bengkulu City

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Abstract

Brownian motion is the random motion of nanoparticles in a fluid that studies the distribution of partcles in stochastic dynamics. The concept of Brownian motion is one of the abstract concepts of physics., making it difficult to learn. The concept of Brownian motion is widely found in everyday life, but Senior High School never teaches Brownian motion. Including the Senior High School 5 Bengkulu City. For this reason, the introduction of Brownian movements with easy to understand language needs to be taught to students learned at increasing knowledge and information. The method carried out in this study is the stage of preparation, implementation, and evaluation methods. From this research, it can be seen that students are very enthusiastic about listening and answering every question asked. It also looks very active. The competitive spirit of the students is also visible. Thus, it can be concluded that, no matter how difficult and abstract Brown's motion, if taught in simple language, then students are also able to understand them well.

Keywords: *Stochastic Dynamics, Brownian Motion, Abstract Concept*

A. Introduction

Brownian motion is the random movement of microscopic particles dissolved in a liquid. Based on the research of Robert Brown, a Scottish Botanist, two results were obtained regarding Brownian motion, namely the irregularity of the particle trajectory in the fluid and the absence of the interaction effect of two different particles [1]. Then Gouy added a few things about Brownian motion, namely the faster the Brownian motion, the smaller the particle. Second, motion is affected by the density and composition of the particles. In addition, fluids with low viscosity accelerate Brownian motion and high temperatures also accelerate the motion. Finally, particle motion never stops [2]. Brownian motion can be observed in nanoparticles that are in certain fluids, for example crushed marbles and then the grains are immersed in water, so the particle motion will be inhibited by fluid viscosity and stochastic forces. This is caused by collisions of molecules moving randomly in the fluid. Stochastic processes themselves are included in the physics of dynamics. Because, physics can be interpreted as an effort to realize mathematical concepts to contextual or scientific concepts that contain numbers [3]. Stochastic processes can also be considered as state space trajectories [4]. The formulation of particle dynamics in a diffusing fluid inevitably has resistance due to the fluid's viscosity and stochastic forces. This is caused by collisions of molecules moving randomly in the fluid [5]. Diffusion in Brownian motion causes the emergence of translational motion in elementary [6]. This perspective comes from the change in probability decicity and random motion isotopes in a quantum volume (ħ) related to the distribution of Brownian motion and the Fokker-Planck equation [7]. Brownian motion with the stochastic concept can also be reviewed using the STA method.

Brownian motion is a material that studies the distribution of particles in stochastic dynamics. Stochastic processes themselves are included in physics related to dynamics. Because physics can be stated as an effort to translate mathematical concepts into contextual or scientific concepts that contain numbers. Stochastic dynamical systems use a lot of modeling data along with systems for future masses [8]. Stochastic dynamical systems or also known as stochastic differentials can be applied to systems that move randomly, especially non-relativistic systems [4]. If Brownian motion is disturbed in the form of an external force, the equilibrium will be disrupted. It took a very long time to get back into balance again.

To be able to speed up the process of evolution of Brownian particles to an equilibrium state, several researchers have started conducting experiments. As done by Martinez et al.

One of the concepts used is the concept of accelerated quantum dynamics, namely Shortcuts to Adiabaticity (STA). This concept was developed by a scientist named Gonzale Muga. This is done by setting one control parameter, usually the control parameter is lambda. By setting these control parameters, additional energy is obtained in the form of additional potential to accelerate Brownian motion back to equilibrium after being disturbed. STA was originally used to achieve the final result in a short time under adiabatic conditions. However, it has now been extended to look for adiabatic shortcuts [9] [10] and developed in quantum dynamics. For example, in tracking without transitions that apply to various initial states and then switch to *overdamped* [11] as in the stochastic system [12] which is being discussed in this Brownian motion. The STA method is used to accelerate the slow Brownian motion in reaching equilibrium. To accelerate the movement to reach a balanced state, there must be a change in control parameters and a change in phase space offset by system adjustments to shorten the time to reach final equilibrium [13]. The STA method aims to develop protocols, both in quantum and classical and allows the system to move as quickly as possible from one *equilibrium* to a new one provided that events occur in adiabatic states [14] [15] and isolated systems [16]. To speed up the*equilibration* and increase power, a method known as *Engineered Swift Equilibration* (ESE) can be used [12].

Based on the results of initial observations and interviews with several students at SMA Negeri 5 Bengkulu City. It was found that Brownian motion had actually been explained indirectly in high school, especially on Atomic material and some Biology material on flower pollen, but had never been discussed in depth or in a special sub-theme, even though the application of Brownian motion was very broad. applied in everyday life. day, such as in traffic flow, cell function, and ecological models [17]. Brownian motion is included in the concept of abstract physics. So students find it difficult to understand. Based on this, the writer is interested in introducing Brownian motion to high school students. This study aims to increase students' knowledge about Brownian motion. In addition, this research which aims to introduce Brownian motion also aims to provide information to students about physics concepts, namely stochastic dynamics and how to accelerate stochastic dynamics using the acceleration method of quantum dynamics in simple and easy-to-understand language.

B. Method

Based on the problems that have been formulated previously by the researcher, the most suitable approach is qualitative. This activity is designed in several stages. Each stage is an interrelated part.

a. Preparation

Stage This preparation stage is to prepare all materials and sources of information both from journals and books and electronic media regarding Brown's motion and prepare media in the form of power points.

b. Practice

Stage The core stage, namely visiting school and starting to get acquainted with students, showing information about Brown's motion through smart TVs while providing brief information accompanied by discussions with students of Senior High School 5 Bengkulu City

c. Stage

At this evaluation stage, asking students to conclude from the discussion that has taken place, then the author adds conclusions to strengthen the knowledge of students. After that, give prizes to students who successfully answer the questions that have been asked. At this stage, it can also be concluded that class XII students at Senior High School 5 Bengkulu City are very active in participating in activities, and they are students who are quick to respond when given new knowledge. This can be seen from the number of students who scramble to answer the questions we ask.

C. Results and Discussion

Implementation of Brown's motion recognition activities that are packaged in community service activities for class XII students of Senior High School N 5 Bengkulu City begins with several reasons. First, the Senior High School 5 Bengkulu city is the best school in Bengkulu Province. This school is famous for various achievements from the regional level to the national level. Thus, the ability of students at Senior High School 5 Bengkulu City is unquestionable and we think this school is capable of accepting this abstract concept of physics. Second, we chose class XII because it is in class XII that they will study quantum material. So, what we will convey can be their initial capital for quantum learning.

Community service activities were carried out on October 24, 2022 at Senior High School 5 Bengku City. Diwali activities with the introduction stage, here we introduce ourselves one by one to students. The students responded with great enthusiasm. In fact, they can immediately remember the names and titles that we introduced that day. It can be seen in the following picture,

Figure 1. Introduction to Students

From the picture above, it can also be concluded that students in class XII of Senior High School 5 Bengkulu city are very enthusiastic about what we are going to convey and these students are typical good listeners. Ambitious and competitive nature among students is deeply embedded in students.

After the introductory session was completed, then the implementation of the provision of material in the form of Brown's motion recognition which was displayed on a smart TV through *power point* was carried out for 1.5 hours. In the process of recognizing Brownian motion, it begins by giving examples of the application of Brownian motion which are often found in everyday life, so that students can understand easily what Brownian motion is. Then, they entered into the abstract material in the form of stochastic dynamics which was explained in light language and easily understood by students. In addition, there is also material in the form of attenuation in the form of *underdamped* and *overdamped* which is explained in the introduction of Brownian motion. In delivering the attenuation material, it is done by direct discussion to students because the material is familiar to class XII students of Senior High School 5 Bengkulu City.

Figure 2. Introduction of Brownian Motion Material to Students

Figure 3. Students are Enthusiastic to Listen to the Explanation of Brown's Motion Materials

Figure 4. *Underdamped* and *Overdamped* Explanations

We choose to spend more time on discussion so that students can participate more in the activities that we do. We also intersperse each presentation of material with a little joke and refresh the brain so that students do not feel bored with the abstract concepts they receive. According to some students, Brown's motion material is very interesting. They are also very serious about listening to the difference between *underdamped* and *overdamped* Brown's motion. According to some other students, *underdamped* and *overdamped* were similar to attenuation in waves. Especially their experiment on rope waves. This makes it easier for students to accept the concept of the two dampings in Brownian motion. Several other students also asked questions related to our material. This proves that the student has a high curiosity. They also said that physics lessons were also fun. From this activity, we can see that physics is actually easy if it can be explained in simpler language.

The last of this activity is to conduct discussions with students and at the same time ask students to conclude the results of the discussions that have taken place during community service activities in the form of introducing Brown's movements in light and easy to understand language. In addition, at the final stage of this activity, feedback is provided to students, where for students who succeed in answering the questions asked, students will get prizes. The author also helps students in concluding and straightening students' answers during the discussion process. All community service activities ended at 12.00 with the closing of the service implementation. And don't forget to hold a group photo session as a documentation of the activities.

D. Conclusion

This service aims to increase students' knowledge about Brownian motion. In addition, this study which aims to introduce Brown's motion also aims to provide information to students about the concepts of physical science at Senior High School 5 Bengkulu City. This is based on students' knowledge of science in physics, especially on Brownian motion which still looks minimal. From the introduction of Brown's movement at Senior High School 5 Bengkulu City, students got a good response. Students were enthusiastic in listening, answering, and asking questions. This proves that abstract physics can be explained with simpler concepts.

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