Newton's cradle pendulum experiment

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Triple axis accelerometers attached to the central balls of a Newton's cradle pendulum reveal, along with the expected horizontal acceleration, an unexpected vertical acceleration following the impact with the first ball. This effect can be explained through a switch in the initially vertically oriented kinetic dipoles in each ball to a horizontal direction as a result of the force of impact. The central balls experience a vertical acceleration because, for a moment, the balls are less heavy since not all their kinetic dipoles continue to push downwardly as before the impact. After transmitting the impact force to the next ball, each central ball switch back its horizontal kinetic dipoles to the initial vertical orientation. The delay between the horizontal and vertical signals provided by the accelerometers also reveal a relaxation time of the kinetic dipoles' change of direction.

The so-called Newton's cradle pendulum is an amazing machine still capable to surprise us after more than 300 years since it was invented. For instance, it can prove the reality of the kinetic dipoles, as described in a proposed model of gravity discussed in [1-4].

A four identical steel balls pendulum was built for the purpose of this experiment. At rest, the balls are slightly touching each other, their centers being perfectly aligned in a horizontal direction, as shown in Fig. 1. The two balls in the middle, which are supposed to almost not move when the end balls swing, have a three-axis accelerometer attached to each of them. The accelerometers' Y axis corresponds to the vertical direction and their Z axis corresponds to the horizontal direction in the plane of Figs. 4-6, 9 and 10.

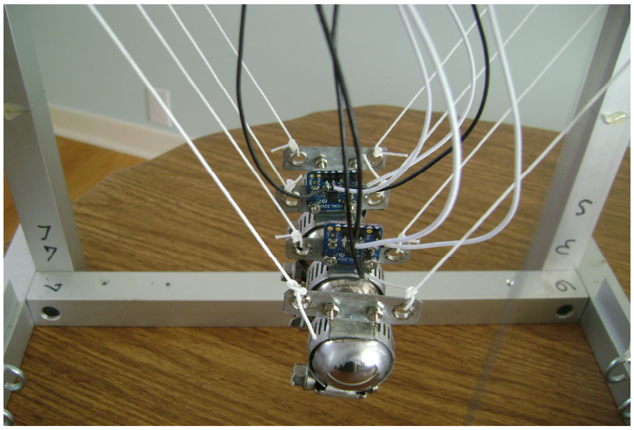

Fig. 1

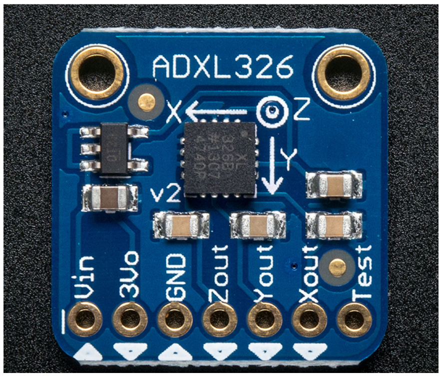

Fig. 2

The accelerometers model ADXL326, as shown in Fig. 2, are powered through tethers with two 1.5 V batteries in series and their Y and Z output signals are recorded with a PCS500 Welleman® oscilloscope/digital transient recorder, as seen in Fig. 3.

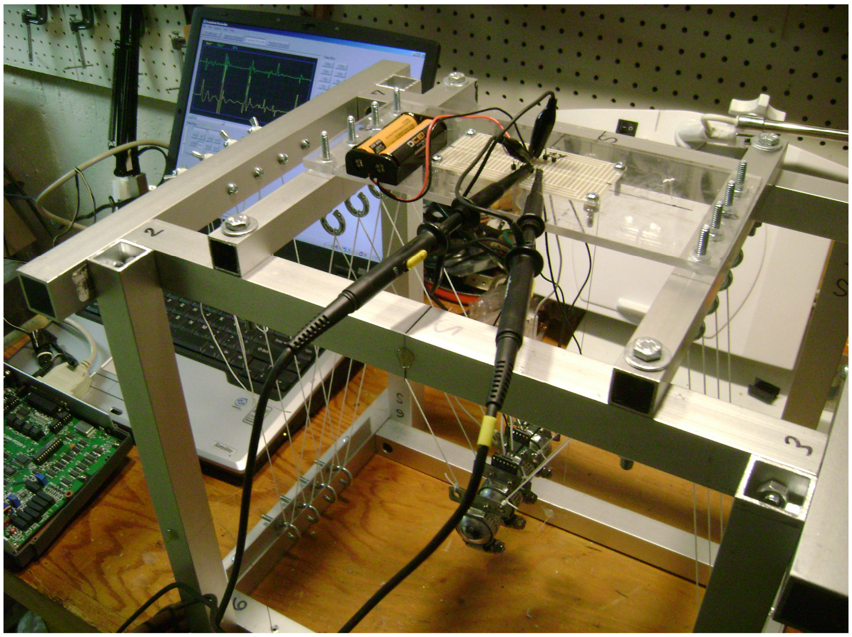

Fig. 3

Fig 4 shows the initial status in which the pendulum is at rest. Conventionally, each ball is shown as containing four kinetic dipoles oriented in the direction of the center of the Earth, pushing the balls downwardly and creating tension in the supporting strings.

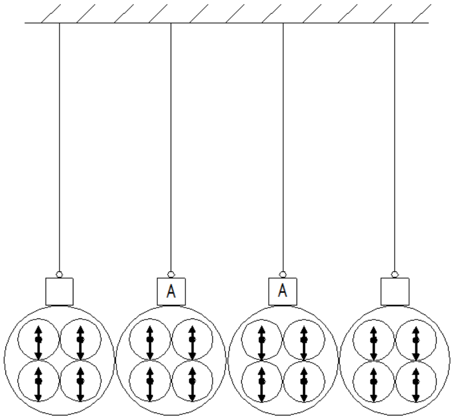

Fig. 4

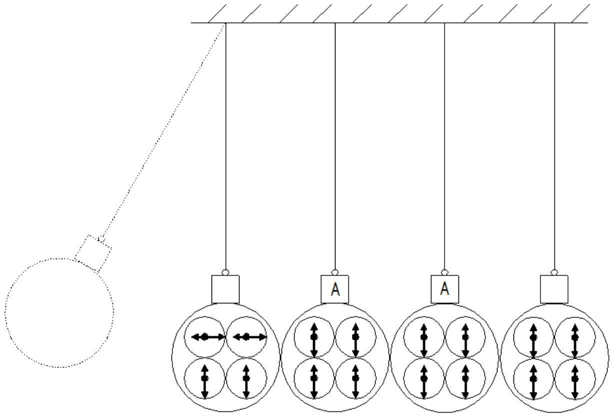

Fig. 5

Fig. 5 illustrates the moment of impact between the first ball on the left and the second ball. Conventionally, half of the kinetic dipoles of the first ball are shown in horizontal position due to the horizontal component of swing motion right before the impact.

Further, the horizontal impact force is transferred to the second ball in which the same number of kinetic dipoles are switched from the vertical to the horizontal direction, as shown in Fig. 6. In this very moment, a horizontal and a vertical acceleration are recorded. While the horizontal acceleration was expected, the vertical one is totally unexpected and there is no evidence that it was ever recorded before this experiment.

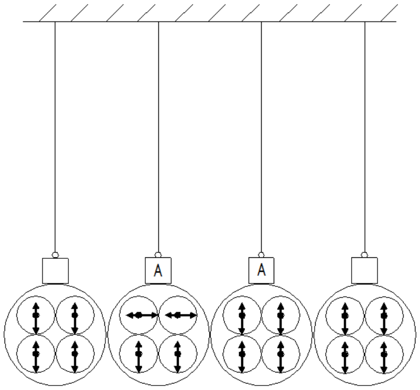

Fig. 6

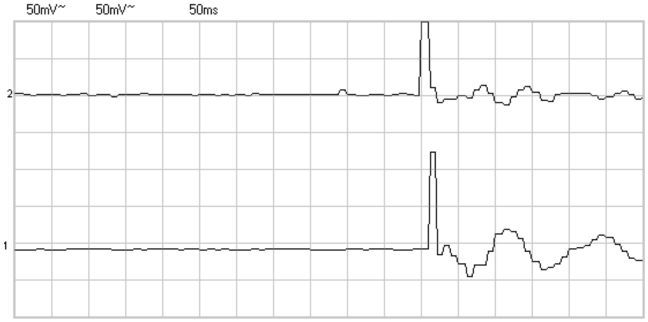

Fig. 7

Fig. 7 shows the logged signals at the output of the accelerometer mounted on the second ball. Channel 1 (bottom) corresponds to the vertical acceleration and channel 2 (top) corresponds to the horizontal acceleration experienced by the second ball after the impact. A positive transient on channel 1 corresponds to an upward motion and a positive transient on channel 2 corresponds to a left-to-right motion, in reference to Fig. 6.

The accelerometers have a sensitivity of 57mV/g and both signals have an amplitude of 135 mV which translates in an acceleration of about 2.3 g. A small delay of about 10 ms is apparent between the vertical and horizontal transients.

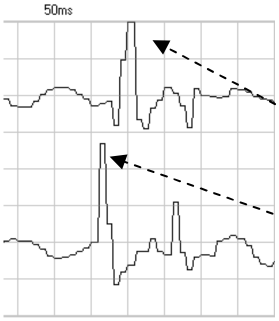

Fig. 8

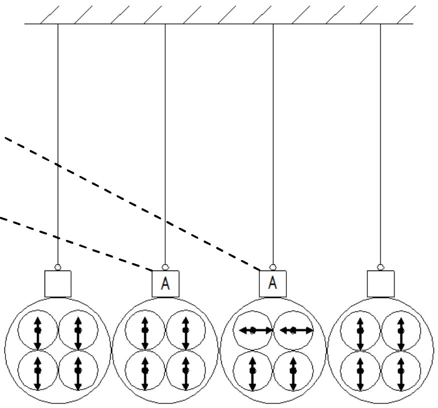

Fig. 9

As expected, the impact force is further transmitted from the second ball to the third ball which also experiences a vertical transient acceleration due to a switch to the horizontal direction of some of its kinetic dipoles, as shown in Fig. 9. The horizontal acceleration transient of the third ball is delayed by 30 ms compared to the transient of the horizontal acceleration of the second ball, as shown in Fig. 8.

Finally, Fig. 10 illustrates the expected swing of the fourth ball as a result of the transmission of the impact force from the third ball which triggers a temporary switch of some of its kinetic dipoles to the horizontal direction.
The delay between the horizontal and vertical transients in each ball (aprox. 10 ms) can be viewed as a relaxation time necessary for the kinetic dipoles to switch from one direction to another. This relaxation time can be a material constant.

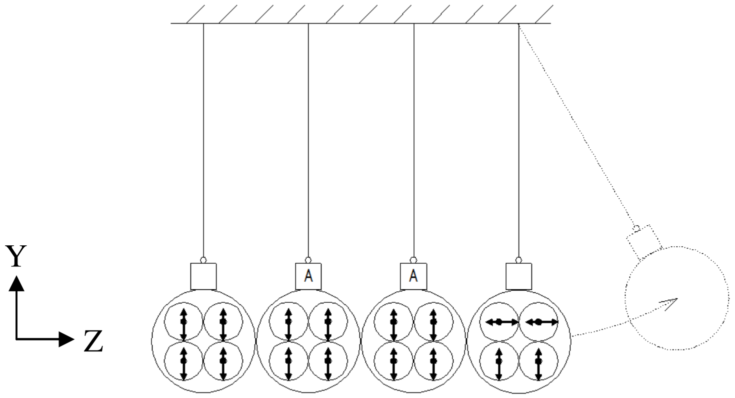

Fig. 10

The remarkable thing is that such a simple experiment using a machine which these days is mainly displayed for entertainment, actually demonstrates that we have to revisit our understanding of notions we take for granted, such as mechanical force, momentum and inertia. The dynamics of macroscopic bodies are a direct manifestation of quantum processes taking place in the atomic nuclei and the concept of nuclear kinetic dipole can help in understanding and predicting them. For instance, the vertical acceleration temporarily experienced by the second and third balls in the above experiment is the confirmation of a prediction.

Any test body immersed in the terrestrial gravitational field has practically all its kinetic dipoles oriented in the direction of the center of the Earth, pushing it from within towards or against Earth's surface. When the kinetic dipoles are diverted in any direction other than that, the test body can experience some degree of weightlessness.

One example is thermogravity, as explained in [5]. By rising the temperature of a test body, the direction of its kinetic dipoles is randomized and the body loses a measurable weight. This effect has a practical use in hot-air balloons and thermal airships.

Another example is the present experiment. As the accelerometers' Y output logs show, the second and third balls lose weight for about 10 ms at a time, experiencing an upward acceleration of about 2.3 g. The process of transmission of the impact force from one ball to another is also intriguing. The force of impact of the first ball is substituted with the sum of the push of a number of kinetic dipoles in the second ball, in horizontal direction.

This process is repeated in each subsequent ball until the fourth ball is pushed and free to swing. As a side effect, the second and third balls experience a short-lived levitation.

We may say that a body's mass can absorb an external force and convert it into the push from within of a number of kinetic dipoles preserving the direction and intensity of the external force after it ceased to act upon the body. This property of mass can be a viable explanation of inertia. In general, a body cannot move in any direction unless it is pushed in that direction by an external force or from within. The classic definition of inertia does not make sense. How can a body continue to move after an external force ceased to act upon it?

Given the fact that a mass is finite, it also follows that a body's capacity to absorb force is also finite since it has a limited number of kinetic dipoles. What happens when the implicit limit is reached? It may happen that said body acts inertially up to that limit and non-inertially beyond that limit, when the external force surpasses the body's force-absorbance capacity.

The above discussion also invites to revisiting the notions of inertial and gravitational mass which will be attempted in a following paper. Also, it invites readers to replicate this experiment with high-performance instruments.

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