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Description of rotation

A logical contradiction in the description of rotational and oscillatory motion has been revealed. Their uncontroversial description is proposed.

Statement of a question

Torsional vibrations are part of the rotation in an unclosed circular path. They are necessarily non-uniform and reversible.

When a circular trajectory is closed, the torsional vibrations turn into rotation. It does not require reversibility and can be proportional.

So, both motion types, depending on the circular trajectory they cover, turn into each other and can be considered (related to each other) as a whole and part.

However, the applied descriptions of these motions differ at the level of logic rupture. Let's compare these physical descriptions.

Pendulum oscillations in the vertical plane

It has the following description.

The deviation of the pendulum from the vertical position by the angle $\propto$ corresponds to the vector decomposition of the gravity P acting on the body into two components: $F_1 = Pcos \propto$, directed along the coupling, and $F_2 = Psin \propto$, directed perpendicularly to the coupling.

Component F_2 returns the pendulum to the state of equilibrium, providing its torsional vibrations. These vibrations are a *reversible, non-uniform rotation* of the pendulum around the circle part.

Component F_1 is balanced by the opposing force of F'_1 of coupling $F'_1 = -F_1$. *The sum of forces acting on the pendulum along the coupling is constantly equal to zero.*

Horizontal rotation of the body

Here the description suddenly changes radically.

It is believed that the body, which rotates *uniformly* along the coupling with the centre of rotation, is no longer affected by two, as in the first case, but by only one force. It is called *centripetal force* and is directed to the centre of rotation.

All physics textbooks always give an image of this single, unbalanced force. It is believed to cause the rotation itself, which is curvilinear and *has constant acceleration*.

It is similar in effect to the returning force F_2 of the vertical pendulum, which oscillates perpendicularly to the coupling.

The circular rotation suddenly appears to be both *uniform* and *having constant acceleration*.

Let's compare again for clarity: *the oscillations are caused by force, perpendicular to the coupling, and rotation is caused by force directed along the coupling.*

In other words: *the force is in or against the oscillatory motion, and it is perpendicular to the rotational motion.*

How this acting *force can cause motion perpendicular to its direction?* That question doesn't even come up.

Another force of rotation, *centrifugal force,* is also mentioned. It arises *based on Newton's Third Law,* is equal in size and opposite in direction of centripetal force.

It is considered that it is no longer attached to the body, but only to *its coupling*.

This is stated in the textbook for university faculties of Physics and Mathematics and of Physics and Technology. Which means the highest possible level of questioning.

Quotes used

Let's look at the relevant quotes. Here is a description of the rotational motion:

"If the motion along the curve is uniform (the speed value is constant, the tangential acceleration is zero), the tangential force is zero, and ***the whole force is centripetal force. This force, acting along the normal to the path, forces the body to turn continuously, without changing its speed value****; if there was no such force, the body would move rectilinearly…* ***According to the Newton's Third Law****, in addition to the centripetal force applied to the body moving along the curve,* ***there is a second force*** *equal to its size, directed in the opposite direction and applied to the body (to those "couplings"), which makes the moving body turn. This force is called* ***centrifugal force. So, the existence of centripetal and centrifugal forces is conditioned by Newton's Third Law; they are applied to different bodies.*** *For example, if a stone tied to a rope rotates, the centripetal force is applied to the stone, and the centripetal force is applied to the rope; if the tram is moving along a rounded path, the centripetal force is applied to the tram, and the centrifugal force is applied to the rails; if the moon revolves around the Earth, centripetal force is applied to the moon, centrifugal force is applied to the Earth" [1],* p. 65-66.

Places requiring comment are shown in bold italics.

Here is another quote describing the oscillatory motion:

"Another example of oscillatory motion is the motion of a flat pendulum (Fig. 240). If the pendulum rod is vertical, ***the gravity*** $\boldsymbol{P}$ ***applied to the weight of the pendulum is balanced by the tension of the rod. However, if the pendulum is deviated from the state of equilibrium by some angle*** $\boldsymbol{\varphi}$*, only a part of the gravity* P *will be balanced by the reaction of the rod, namely, the gravity component* Pn*, parallel to the rod. The component* $P\tau$ *perpendicular to the rod, which is numerically equal to* $P\sin\varphi$ *and is directed to the state of equilibrium of the pendulum, remains unbalanced. If the angle* φ *is small, the sine can be replaced by the angle itself, then* $P\tau$ *is approximately equal to* $P\varphi$*. Here, the shift of the pendulum weight from the state of equilibrium is determined by the angle* $\boldsymbol{\varphi}$*. The force returning the pendulum weight to the state of equilibrium is proportional to the angle* $\boldsymbol{\varphi}$*, if the angle* $\boldsymbol{\varphi}$ *is small.*

Under this force, the pendulum will oscillate near the state of equilibrium. In this case, the motion is not determined by the elastic force, but by the component of gravity $P\tau$*, which is directed to the state of equilibrium and is proportional (if the angle* $\boldsymbol{\varphi}$ *is small) to the deviation of the pendulum from the state of equilibrium. So, the nature of this force is like that of elastic force. The nature of oscillations caused by this force (if the angle* $\boldsymbol{\varphi}$ *is small) coincides with the nature of oscillations caused by the elastic force.*

Forces that are not elastic in nature, but are similar in their type of shift dependence, are called quasi-elastic.

These examples show that the action of elastic or quasi-elastic force causes oscillatory motion" (same, p. 373, 374).

Of course, textbooks in the usual sense are not read, they are simply memorized, taking on faith what is considered to be knowledge afterwards.

Another quote:

"However, it should be noted that the nuclear model does not conform to the requirements of classical electrodynamics. The fact is that the electron rotating around the nucleus ***experiences acceleration and therefore*** *(reference) must emit electromagnetic waves*

and lose its energy. As a result, its motion will be unstable, and it must fall to the core. Since real atoms are very stable formations, ***it follows that*** *the laws of classical electrodynamics, established on the basis of observations of macroscopic processes,* ***are inapplicable to intraatomic processes"*** *[2],* p. 534.

Another quote:

"The assumption that the atom may be in a number of stable (stationary) states characterized by certain energy sizes W_i, as we have seen, is confirmed by direct experiments. At the same time, ***such states are impossible from the point of view of classical electrodynamics****... Being in one of the stationary states of motion, the electron does not emit,* ***contrary to the requirements of classical electrodynamics****... The justification of these hypotheses is that they lead to numerical values of frequencies ν_{ik} that exactly coincide with their values found from the experience"* (same, p. 550).

Some physicists may have a different understanding from that quoted. But the fact remains that this statement did not raise any objections or any clarifying questions. An example that clearly demonstrates the logical problem.

So, the existing description provides the following understanding:

1. When the body moves *uniformly* around the circle, a *centripetal* force *directed to the centre of the circle* acts on it. This force causes the body to move along a circular path *with constant acceleration*.
2. *A centrifugal force directed from the centre of the circle* acts on the coupling of the body to provide its rotation.
3. According to Newton's Third Law, these forces are equal in size and opposite in direction.
4. They are considered to *be applied to different bodies.*
5. Only the centripetal force acting from the coupling side is applied to the rotating body, and only the centrifugal force acting from the body side is applied to the coupling, *but not to the body.*

Although the oscillatory motion is part of the rotational motion, its description has no mention of centripetal and centrifugal forces forming the rotation. This could only be attributed to the adaptation of the narrative, but still it is rather an indication of the incompleteness of understanding.

That is not surprising, as both applied descriptions are given almost in times of Galilei, at the very beginning of formation of physics. Its incompleteness, which is natural for its time, now seems unacceptable.

Proposed description

The following understanding is proposed:

1. The body rotation generates *centrifugal force directed from the rotation axis*. It is easily established experimentally by placing it between the body and the spring dynamometer coupling. Exactly like the effect of gravity on the pendulum body. Its effect on the body is completely similar to that of gravity along the pendulum coupling.
2. The centrifugal force is balanced by *the centripetal force* generated by the coupling.
3. Both body forces are equal in size and opposite in direction.
4. The sum of the forces acting on the rotating body along the coupling *is always zero.*

5. The body moves uniformly, i.e. *without acceleration* along a circular path, which fully explains the "mystery" of the atom stability, which is considered insoluble. In case of a circular path, it is an ***inertial Galilean motion*** [3].

This is like the sum of forces acting on the pendulum body along the coupling. There is no more logic rupture here. The body has no motion along the coupling and moves only perpendicular to it.

When the body rotates *uniformly*, the force acting perpendicularly to the coupling is also zero. This and only this is the difference between *uniform* rotation and oscillatory motion. The latter is not uniform, because it occurs *under the action of force* directed along the motion. It does not also have constant acceleration because this force *is not constant* in direction and size.

This is the clarification relating to rotational motion.

As for the torsional vibrations of the pendulum, it still occurs under the influence of the elastic force $F_2 = Psin \propto$ directed perpendicularly to the coupling.

However, there is more than one force F_1, projection of gravity P on the coupling direction ($F_1 = Pcos \propto$), acting along the coupling, but the sum of forces $F_1 + F_3$, directed from the axis of angular rotation, where F_3 is the centrifugal force determined by the formula $F_3 = \frac{\mathrm{m}V^2}{\mathrm{R}}$, where R is oscillation radius determined by the length of the coupling.

These forces acting on the pendulum body are balanced by the coupling reaction: $F_1 + F_3 = -(F'_1 + F'_3)$, so that the sum of forces directed along the coupling is always zero.

This is the clarification relating to the description of the torsional vibrations of the pendulum.

Rotational–vibrational motion

In addition to the circular motion, there is a closed motion along the elliptical path. It is formed by independent uniform rotation on a circle with radius R, equal to a semi-minor axis of an ellipse, and linear harmonic motions concerning this circle along the major axis of an ellipse.

Mathematically uniform rotation along the circle is represented as a sum of two linear harmonic motions with a phase difference π:

$$x = R \sin \propto,$$
$$y = R \cos \propto,$$

where x and y are Cartesian coordinates of rotational motion with the center of rotation at the origin of coordinates,

R is amplitude of oscillatory motion equal to the radius of rotation,

ω is angular rotation speed equal to $\frac{V}{\mathrm{R}}$,

V is circular motion speed.

Both harmonic motions exchange vibrational energy, but their sum gives all the time the energy remaining constant.

Therefore, uniform rotation is physically inertial, not accompanied by energy exchange.

The movement along the elliptical path is expressed by formulas:

$$\mathrm{x} = (\mathrm{R} + \Delta\mathrm{R}) \sin \omega t = \mathrm{R} \sin \omega t + \Delta\mathrm{R} \sin \omega t,$$
$$y = R\ cos\ \omega t\ ,$$

where ΔR is the difference between the semi-major and semi-minor axes of an ellipse.

It is rotational–vibrational motion formed by two motions: uniform inertial rotation along a circular path with a radius R equal to the semi-minor axis of the ellipse and linear harmonic motions with amplitude ΔR relative to the circular path along the major axis of the ellipse.

This oscillatory motion is non-uniform and reversible, has force and acceleration varying in size and reversible in direction and has internal vibrational energy exchange and transition of potential energy to kinetic energy and back.

References:

1. S.E. Frisch and A.V. Timoreva, Course of General Physics, Volume I, State Publishing House of Technical Theoretical Literature, Moscow, 1955, p. 65-66, 373-374.
2. S.E. Frisch and A.V. Timoreva, Course of General Physics, Volume III, State Publishing House of Technical Theoretical Literature, 1951, p. 534, 550.
3. Somsikov A.I., Law of inertia http://viXra.org/pdf/1909.0394v1.pdf.