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Non-electromagnetic force interaction in presence of rotating masses in vacuum

Vladimir N. Samokhvalov[1]

***Abstract*—We present the results of experimental research of interaction of rotating disks made of non-ferromagnetic materials, which have variable quadrupole moment, and their force effects on moving masses in moderate vacuum, which causes the occurrence of rotation and repulsion of solids from rotating masses. Experimentally ascertained value of mass-dynamic repulsive force, affecting the screen by (160 1/s) rotating disc, weighing 50 g, was about 2,5...2,7 N, and the value of mass-dynamic torsion, torque was about 1 N·cm. That was by 20 orders more than the value of the gravimagnetic force determined by general theory of relativity. On the grounds of experimentally ascertained force effects, we can assume that a type of interaction under the condition of the presence of a relative mass movement similar to a relative electric charge movement plays an important role in nature.**

I. Introduction

According to Einstein's general theory of relativity, the rotating mass field differs from non-rotating mass field by additional, so-called, gravimagnetic forces , which affect rotating objects ([1] p. 191). Taking this fact into consideration, it is assumed that gravimagnetic forces act only if they are close to large masses or in presence of masses moving at relativistic speed, and they do not exhibit themselves in nature because of their extremely small values. However, many researchers in their works mentioned facts, which showed significant non-electromagnetic interaction of small objects, rotating at low speeds, with each other and with the objects, surrounding them.

One of the first evidences of such kind was the experiments of Professor N.P. Myshkin, which were carried out at the beginning of the XX century [2]. The effect of change in weight of rotating objects (gyroscopes) and their non-electromagnetic interaction with other objects are described in works by N.A. Kozyrev [3], V.V. Roshin and S.M. Godin [4], S.V. Plotnikov [5], etc.

The experimental research, carried by the author [6], [7], also showed that in nature there is a significant value contactless interaction of rotating small masses and their force effect on closely located objects (masses) at relatively small rotary and linear speeds of rotation. The value of occurring mass-dynamic forces is by 20 orders more than the value of gravimagnetic forces, which act in this case according to general theory of relativity.

Below we present the results of our experimental research of interaction of rotating dynamically imbalanced discs, made of non- ferromagnetic materials, in moderate vacuum, and their effect on moving masses. Carrying out the experiments in vacuum was conditioned by the necessity of maximal elimination of medium viscosity and gas-dynamic effects on observed process nature and value.

Experimentally determined non-electromagnetic interaction was called mass-dynamic interaction, because it is determined by dynamic mass rotation, having a variable quadrupole moment. The research, which was carried out, showed non-electromagnetic nature of force interaction, i.e. independence of interaction force effects from electrical conductivity of disc materials and dependence of force interaction value on their rotation frequency.

II. Experimental equipment and tools

When we carried out our experiments, different devices were used, which were placed in a cylindrical case of a thick-walled vacuum chamber. The inner diameter of the vacuum chamber was 300 mm, the length of it was 780 mm, and the thickness of its walls was 15 mm. All the devices were rigidly fixed or placed in thrust inside the chamber, which allowed elimination of the vibration occurrence in the experimental equipment. The chamber butt end was covered by a removable transparent flange, through which we carried out our observations, took photos and made video filming. The current feedthrough to electric motors from the DC power supply, located outside the chamber, was provided through hermetic adapters on the flange. Inside the chamber lighting halogen lamps were installed, which were connected to a separate DC power supply.

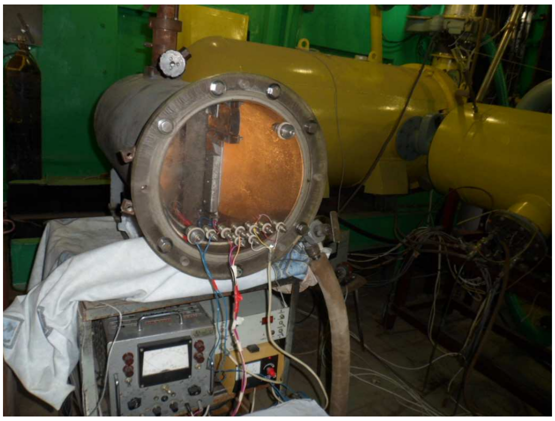
Initially, the experimental research was carried out in the laboratory of Samara State Transport University. The overall view of experimental equipment is shown in Fig. 1, a. Air pumping was carried out by AV3-20D forepump, which allowed to provide a residual pressure of 0,05 Torr. Afterwards, because of the necessity to provide a deeper vacuum, our experiments were continued in the Space Energetics Research Centre of Samara State Air-Space University (National Research University).

The same small vacuum chamber and experimental device were used which the author had used before in the

[1] Samara State University of Transport 18, Pervy Bezymyanny pereulok, Samara, 443066, Russia, *samohvalov_ vn@mail.ru*

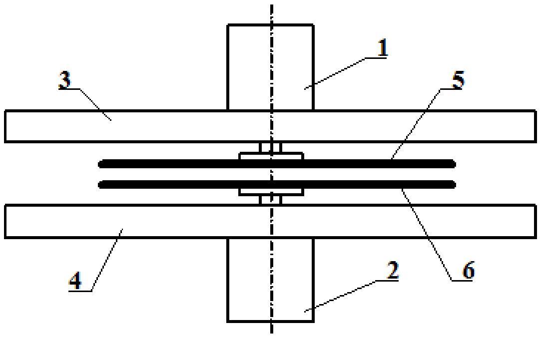
laboratory of Samara State Transport University. But that vacuum chamber was connected to a bigger one at the national research centre (Fig. 1, b), which has two-stage system of vacuumizing. Initial air exhaust was carried out by a vacuum forepump NVZ-300 up to 0.1 Torr and then some deeper vacuum (up to 0.0008 Torr) was supplied to the chamber by a booster oil-vapor vacuum pump 2NVBM-160. The control and the measurement in the chamber were carried out by a thermocouple vacuum gage VT-2A-P.

(a)



(b)

Figure 1. Experimental equipment.



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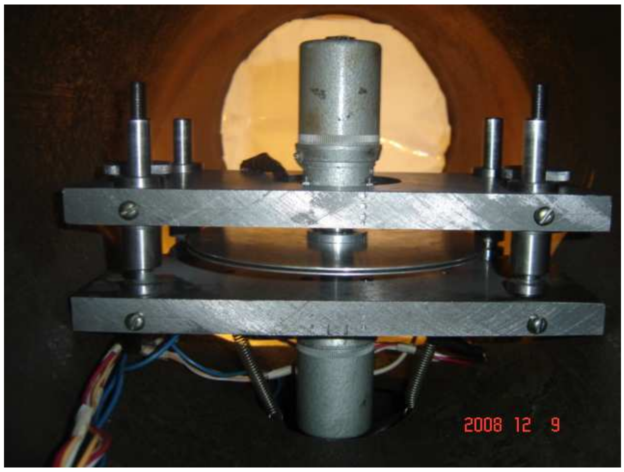

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Figure 2. Basic diagram and overall view of device for mass-dynamic effect research.

III. Force interaction of rotating disks

Residual pressure in vacuum chamber was approximately 0,05 Torr. In our experiments we used a device (Fig. 2) which comprised two direct-current motors D-14FT2s (1 and 2), having electromagnetic brakes, and mounted on steel plates 3 and 4 with the thickness of 18 mm.

The disks (5 and 6) had their diameters of 165 mm and their thickness of 0.9 mm, they were made of aluminum alloy AMg3M, and they were firmly fixed on the flanges of the motor rotors. The motors were connected to DC power supply V5-48, located outside the chamber in order to maintain a set steady voltage. A separate power supply was used to activate or deactivate the motor electromagnetic brakes.

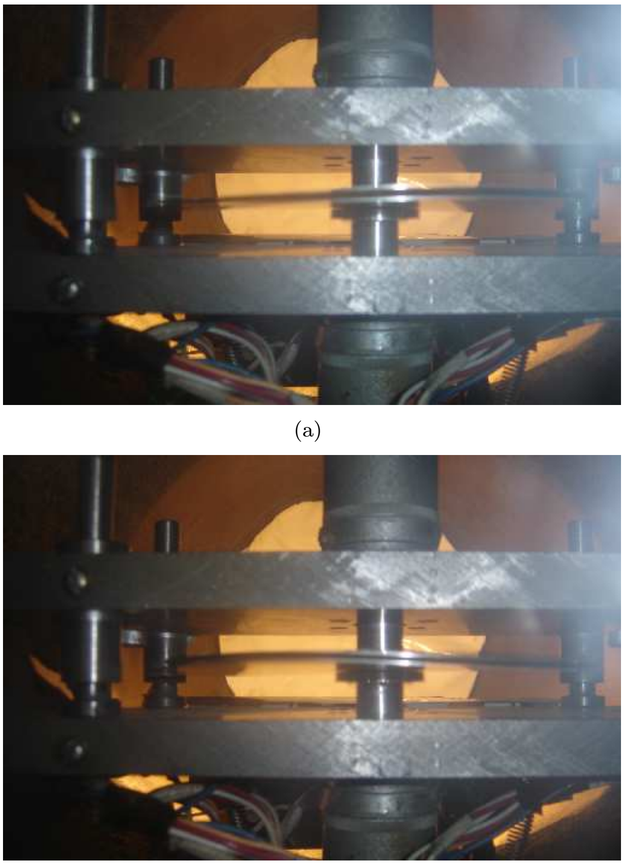
The distance between the disks was set by parallel movement of electric motor fixing plates on four steel columns, with subsequent rigid fixation. The distance from the disks to the plates was not less than 20 mm. Alongside with that, in some experiments we set a deliberate misalignment of the disk axes relative to their electric motor axes, which created a variable quadrupole moment of rotating discs, while in some other experiments the highest possible disk parallelism and dynamic balance were provided. The initial gap between the disks was set from 1 to 6 mm and more. The possibility of mechanical contact during the disk rotation, taking into account their imbalance, was excluded.

In the first series of experiments, the feeding voltage was supplied to both electric motors simultaneously. If the initial gap between the disks is 1-3 mm and the simultaneous voltage supply is 30 V on both electric motors to rotate them in opposite direction (counter rotation), they are initially accelerated up to a maximum speed of approximately 100-120 1/s. Then periodical vibration of one of the disks, or simultaneous vibration of both disks occurs. Disks vibration frequency is approximately 10-20 1/s. The disk rotation speed dramatically falls by approximately 2 times (50-60 1/s) during the vibration.

A considerable disk surface bending i.e. their elastic deformation is observed during this process. The vibration of one disk is chaotic relatively to the other. The gap between the disk surfaces in different zones is a time-varying parameter.

In this case a mechanical contact between the disks did not occur even if the initial gap between the disks was 1 mm. The disks repelled from each other and each disk was rotating in its own direction. When the vibration stopped the disk rotation speed increased again. The process repeated with certain periodicity.

At some moments the disk chaotic vibrations became relatively stable – the disk spiral twist, rotating with a frequency of 1-3 1/s (Fig. 3)[1].



(a)

(b)

Figure 3. Disks surface bending and twisting during simultaneous counter rotation in vacuum.

In this case, a synchronous distortion of both disk planes occurred. As it can be seen in the photographs and in a slow video of this process, the distorted disk surfaces are almost equidistant. That is, spiral surfaced disks, rotating in opposite directions at a speed of 90-100 1/s, flow around each other without any mechanical contact, a wave of the disk mechanical elastic deformation moves along the surface at the same angular velocity as the disk angular velocity. And the rotation of the spiral twist is in the direction of the disk rotation, which had a higher rotation frequency.

If the disks were deliberately imbalanced (a small misalignment of the disk axes and the rotors axes were set), the above-described effect of the disks interaction (vibration excitation, and then flexural wave occurrence) was observed when the gaps between them were up to 3 mm. In experiments under the same conditions, but in the absence of vacuum (standard pressure in the chamber) these effects did not occur. The strong disk vibration was not excited, and a flexural wave was not observed even when initially set gap between the disks was less than 1 mm.

When one of the electric motors (rotating in vacuum) was switched off, and its disk was stopped, the second electric motor started spinning up to a maximum frequency of approximately 180-200 1/s. When the first electric motor was switched on, the rotating frequency of the second electric motor decreased again. The rotation frequency of both disks was approximately 90-100 1/s. Thereby, during experimental recurrence, it was experimentally ascertained that during simultaneous rotation in vacuum a sufficiently strong mutual disk slowdown was observed.

While the feeding voltage of 30 V was supplied simultaneously to both electric motors to rotate their disks in the same direction, after complete spinning only a strong vibration of both disks was observed. The distortion of the disk plane bending was not observed.

The electric motor rotation frequency was also significantly less than the maximum frequency. When the power supply of one of the electric motors was switched off, the second electric motor spun up to the maximum frequency. When the motor was switched on again, all the effects recurred completely.

If one of the electric motors was switched off and blocked, then after the voltage of 30 V was supplied to the second electric motor and after its complete spinning, a slight disk vibration began, and then a slight vibration of fixed disk was periodically excited. When the fixed disk vibration was excited, there was a visible decrease in the rotating disk frequency.

In the second series of experiments, the voltage was supplied to only one of the electric motors, while the second one was switched off and unblocked.

It was experimentally ascertained that if in vacuum a (driven) electric motor was switched off and unblocked, when the second (driving) motor was supplied with the voltage of 30 V and completely spun, the forced rotation of the first disk with its electric motor rotor began[2].

It was revealed that the effect of excitation of forced rotation and rotation frequency, with other conditions remaining the same, depends on the degree of the disk dynamic balance. The experiments showed that, with a sufficient high degree of the disks dynamic balance and

[1]See http://www.youtube.com/watch?v=-O_PnrAa1lM.

[2]See http://www.youtube.com/watch?v=ochBewD6tVw.

the absence of disc vibration at a maximum spin, when the disk gap was more than 2-3 mm, the forced rotation of the driven disk was not excited.

If the gap between disks was 1.0-1.5 mm and the driving disk was completely spun, a driven disk slow turning with a frequency less than 0.05 1/s was observed. When the driving disk vibration occurred, a driven disk began rotating with a frequency of 5-10 1/s. If the driving disk vibration increased, the driven disc frequency increased up to 20-30 1/s.

At the same time it was ascertained that with a relatively small disk dynamic imbalance the forced disk rotation was excited with the disks gap up to 3 mm. The forced rotation frequency, with other conditions remaining the same, depends on the initial gap between the disks, the less it is, the higher is the rotation speed. When the gap between the disks was more than 4 mm, even strong disk vibration did not result in forced rotation excitation of the driven disk.

Thus, the force effect of the driving disk, rotating at a high speed, on mechanically contactless driven disk, resulting in its rotation in vacuum, was experimentally ascertained.

The value of torque was sufficient to rotate the electric motor with the driven disk. The counteraction to this torque, to stop the forced driving disk rotation, required voltage supply to the driven motor, connected with it, which was equal to 0.2-0.8 of the voltage supplied to the electric motor of the driving disk, depending on the gap between the disks and the degree of their imbalance. When the voltage supply of the driving motor was 30 V, to stop the forced rotation of the driven motor with the gap between disks of 1.5 mm, the voltage supply of 12–18 V to the driven disc was required for counter-rotation, and when the gap between the disks was 3 mm, the voltage supply was 5–11 V. When the voltage supply of the driven electric motor was further increased, its disk started to rotate in its own direction (oppositely to the driving disk).

These experiments were repeated without vacuum (under the standard atmospheric pressure in the chamber). While the feeding voltage of the electric motors was the same, the disc rotating speed was lower. The disk vibration did not occur. The forced rotation of the driven disk was not excited, even when the gap between the disks was less than 1 mm. Under these conditions, only a slow turning of the driven disc with the rotation frequency of less than 0.1-0.3 1/s was observed, i.e. significantly lower than in the case of the driven disk forced rotation in vacuum.

Thereby, as a result of experimental recurrence, it was ascertained that the forced rotation of the initially motionless disk is the consequence of its contactless force interaction with the rotating disk in vacuum. In the absence of vacuum (in the presence of air in the chamber) the forced rotation of the initially fixed disk with a closely located disk, rotating at a high velocity was not excited.

When one disc or both discs, made of dielectric materials (cardboard, paper, plastic) were used, all the force interaction effects of discs, made of aluminum, recurred in their qualities. The quantitative differences were conditioned by their rigidity and weight of discs.

When we varied the disc rotating speeds (by altering feeding voltage or by brief disconnection and the following powering on of one of the electric motors), a transfer of chaotic disc vibrations to their synchronous distortion in the process of rotation (the above-described flexural wave) was achieved. Herewith, a significant surface bending of both aluminum and paper discs was observed. This can be clearly seen while viewing the video of the process. Herewith, despite considerable vibration amplitude of the discs, the mechanical contact between the discs did not occur. The discs with bent surfaces, rotating in opposite direction, seemed to flow round each other.

A peculiar effect was observed when the lower disc was made of elastic material (plastic with thickness of 0.2 mm). Herewith, the interaction of counter-rotating discs entirely recurred. However, later, the plastic disc (during its rotation) began to cover the flange, on which it was fixed, and then it went down, increasing the gap with the upper disc from initial 1.5 mm up to 5 mm. Herewith, due to the influence of centrifugal forces it remained horizontal. This can probably be explained by the repulsive forces, which occur between the discs during their counter-rotation. Also the absence of mechanical contact under considerable vibration amplitude of disc surfaces during their counter-rotation can be explained by the effect of repulsive forces.

In the last series of experiments, the upper disc was hung on threads, while the lower disc was rigidly fixed on the flange of the electric motor rotor, and it had a slight dynamic imbalance. The upper electric motor was initially blocked, i.e. the upper disc did not have the possibility to rotate, except for a small spin due to the thread elasticity. The lower electric motor was fed by 30 V voltages.

When the gap between the discs was quite big (2.5 - 3 mm), after the lower disc acceleration, a significant precession of the upper (non-rotating) disc axe began. When the initial gap between the discs was small (1.5 - 2 mm), the precession of the upper disc began almost instantly after the lower disc acceleration[3].

When the axis precession occurred, the upper (non-rotating) disc rose up to the contact with the flange, to which the thread hanger was attached, and the central axle went beyond the disc thickness. The mechanical contact between the discs did not occur even with the maximal precession amplitude. The rise of the center of mass, in the absence of its rotation, and the constant presence of the gap between the disc surfaces indicate the repulsive force effect from the rotating lower disc on the lower disc during the precession.

After the upper electric motor was unblocked, within 1 - 3 s upper disc forced rotation began. When the forced rotation frequency of the upper disc increased, the rotation frequency of the lower electric motor increased either. The rotation frequencies of the upper disc were up to 20 -

[3]See http://www.youtube.com/watch?v=h7IKQymgb4c.

30 1/s, while the rotation frequencies of the lower disc were up to 100 - 120 1/s. That is, after forced upper disc acceleration, the driving lower disc accelerated too (under the same feeding voltage). Thereby, a significant precession of the driven (upper) disc considerably decelerated the rotation of the driving (lower) disc[4].

Under forced rotation of the upper disc, with the rotation frequency increase, the precession amplitude of the upper disc decreased up to minimal values. Herewith, the gap between the discs considerably exceeded the initial gap, and the butt end of the central axle went beyond the disc thickness, although this gap was less than during the precession in the absence of the upper disc forced rotation.

The gap enlargement between the disc surfaces, in this case, occurred due to the spin of the disc, hung on the threads, around the central axle, as a result of the torsion torque effect from the rotating lower disc. In addition, the above-described disc repulsion could partially remain, as a slight upper disc precession remained.

When the upper disc was abruptly decelerated and then stopped (after switching on the upper electric motor electromagnetic brake) the upper disc precession instantly achieved initial values (as with its initially decelerated electric motor).

These effects in the presence of air, under other equal conditions, were not observed. Only an insignificant upper disc forced rotation occurred (with the frequency of 0.05 – 0.1 1/s). This rotation occurred only with a minimal gap between the discs, which appeared due to the aerodynamic force effect – because of the pressure decrease in the gap between the discs during the lower disc rotation. The precession of the upper disc axle was not observed here.

Afterwards, the upper disc was placed on a bellows – cross-corrugated sheath. Such a design allows passing a torsion torque from the electric motor to the disc, but at the same time it makes the axial disc movement possible, and allows vibrations relative to the arbitrary horizontal axis due to elastic compliance of the bellows. The bellows was made of stainless steel, the thickness of its walls was 0.25 mm, and the outside flute diameter was 27 mm. Both discs were made of AMg3M aluminum alloy. The disc diameter was 164 mm, and the thickness – 0.9 mm. Here all the interaction effects, previously established for rigid fixing design and the upper disc thread hanger recurred in their qualities.

After the lower disc spinning up to the frequency of 130 – 150 1/s, the axial precession of the non-rotating upper disc, placed on the bellows, began, with the frequency of 5 – 10 1/s. Herewith, the value of axial vibration of the disc butt end was up to 5 – 6 mm. This was much more than the initial gap between the discs, but the upper disc didn't come into contact with the lower disc[5].

Everything above-mentioned indicates that due to the sheath elastic deformation of the bellows the average distance between the discs increased, i.e. the repulsion of the discs took place. A considerable bellows elastic deformation means the effect of rather high pressure on the upper disc from the rotating dynamically imbalanced lower disc, i.e. the pressure of mass-variational (quadrupole) radiation of the rotating mass.

When the upper electric motor unblocked (without power supply to its coils), the upper disc began its forced rotation in the same direction with the lower disc, the frequency of rotation was 1 – 3 1/s, and the value of its precession decreased. The above-described disc interaction was observed when the initial gap between them was 1.5 – 4 mm.

When the initial gap between the discs was 5 mm slight precession of the upper disc occurred, but its forced rotation was not excited, i.e. the value of induced torsion torque was insufficient for the upper disc forced rotation together with the rotor of its electric motor.

The disks were made of nonmagnetic material and, therefore, other known force interactions were excluded (Barnett effect, etc.).

Analysing the aforesaid experiment results we can ascertain the following:

1. It was experimentally ascertained that in vacuum the driving disk rotating at a high velocity has a significant force effect on the closely located driven disk which did not have a mechanical contact with the driving disc. The value of the torque, produced in this process, was sufficiently greater to not only rotate the motor with the driven disk, but also result in the rupture of the disk suspension. When the disk gaps were small, the counteraction to the torque required the voltage supply to the connected electric motor, which was equal to 0.3–0.8 of the voltage supplied to the driving disk electric motor, depending on the gap between the disks and the driving disk imbalance.

2. All the effects, above mentioned, occurred when the disks were rotated in the vacuum. When the disks rotated at a standard atmospheric pressure in the chamber, the disk high-amplitude vibration did not occur, and the plane twist did not occur either. Furthermore, the forced rotation of one disk at a maximum velocity of the other disk rotation is not excited. A slight excitation effect of forced rotation with the frequency less than 0.05–0.1 1/s was observed in the air when the gap between the disks was less than 1 mm.

IV. Force mass dynamic interaction of rotating disc and rigidly placed screen

Setup (Fig. 4) includes the dynamically imbalanced disc made of aluminum alloy AMg3, with the diameter of 164 mm, the thickness of 0.9 mm, and the mass of 50 gr, being rotated by a direct current electric motor D-14FT2c ($U = 27V, n = 12500$ rpm). Electric motor was connected to the source of direct current supply located outside the chamber, which allowed maintaining stable preset voltage. The experimental setup was placed in thrust inside the vacuum chamber. The thickness of the chamber walls (15 mm) and its great mass together with the rigid placement

[4]See http://www.youtube.com/watch?v=o9bUi1agnYw.

[5]See http://www.youtube.com/watch?v=yi3s1RcqLEw.

of the gage almost excluded its vibration while the disc was rotating, which had dynamic (moment) imbalance.

The screen was fastened on the rigid and firm console: a steel plate with the cross-section of 5x12 mm. The console had an additional support made of bimetallic wire being in contact with the inside surface of the vacuum chamber, it was made to exclude the turn of the console which was clamped by screws. A copper plate with the thickness of 1.3 mm fastened on the cardboard substrate was turned towards the surface of the rotating disc.

As the experiments showed while the screen was placed with the clearance of 2 mm from the disc surface, after the beginning of rotation with the supplied voltage U = 30 V of the electric motor, flexural vibration with the amplitude up to 1 mm was excited. However, the vibration intermittently transformed into a flexural wave similar to that which occurred during the interaction of two discs having opposite rotational direction. The amplitude of the flexural wave was about 1 mm under the frequency of its rotation 1...3 1/s (the frequency of the disc rotation was approximately 120...150 1/s). The vibration of the screen was not observed. The mechanical contact of the disc with the screen did not occur. The copper surface of the plate was treated with fine sandpaper to obtain matted surface before each experiment. It was made in order to register traces of mechanical contact of the screen with the rotating disc if they occurred during the experiment.

When fastening the screen with a clearance of about 1,5 mm from the disc surface, after the beginning of the disc rotation with the feeding voltage U = 30 V a strong flexural wave was excited. The observed flexural wave frequency on the disc was 1...3 1/s while its amplitude was up to 1.5 mm which resulted in intermittent contact between the disc and the screen[6].

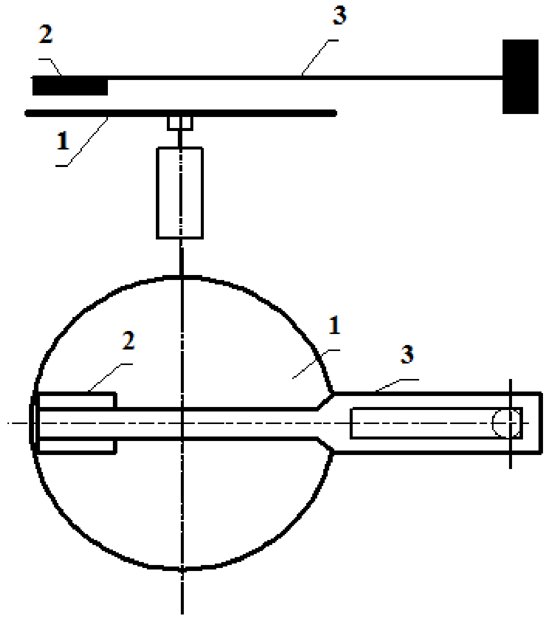
When fastening the screen with a clearance of more than 3 mm from the disc surface the described above effect did not occur. After the beginning of the disc rotation even under the high electric motor voltage feeding (U= 35...40 V) and the high disc rotation frequency (up to 180 1/s), a flexural wave on its surface was not excited, i.e. a flexural wave is a consequence of a force interaction of the rotating dynamically imbalanced disc and the screen. The force interaction falls sharply with an increased clearance between the objects owing to a shielding effect of the residual medium in the vacuum chamber like in our former experiments.

Since the screen was almost motionless (in some cases with minor clearances there is a small forced vibration), so it could not generate considerable mass-variational radiation. Therefore the flexural wave excitation was the consequence of the mass-variational interaction (variable mass-variational) field of the rotating dynamically imbalanced disc, with an induced mass-variational field in the screen material.

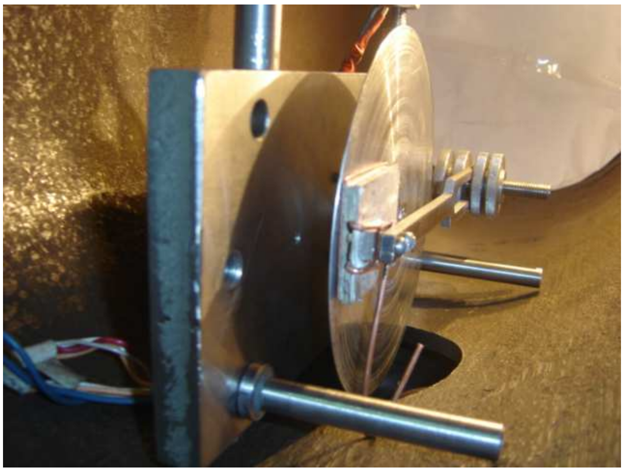
Since the screen had a small surface area, it resulted in localization of the effect of the mass-dynamic forces on the screen surface which resulted in flexural wave occurrence on the rotating disc surface due to its relatively low rigidity.

Without the screen or if it was placed at a distance enough to absorb the energy of the quadrupole (mass-variational) radiation of the residual air medium, the flexural wave on the gyrating disc did not occur.

The value of the force interaction of the rotating dynamically imbalanced disc and the screen is sufficient not only to excite the strong flexural wave. As the measurement of the disc geometry showed after carrying out of 20 experiments (according to above mentioned diagram), initially the flat disc surface transformed into a dome-shaped one (Fig. 5), i.e. a plastic deformation of its material



(a)



(b)

Figure 4. Basic diagram (a) and overall view (b) of gage with rigidly placed screen: 1 – rotating disc, 2 – screen, 3 – screen fastening console.

[6]See http://www.youtube.com/watch?v=CTF76t3YcA4.

(aluminum alloy AMg3) occurred. The dome height was approximately h=2.4 mm. Since the wall thickness of the disc equaled 0.9 mm, hence the dome sagitta was about 1.5 mm.

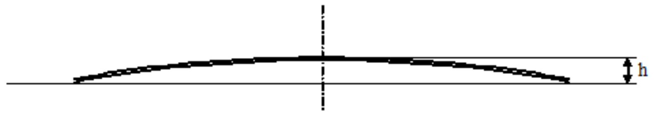


Figure 5. Disc generating shape after its deformation by quadrupole radiation pressure reflected from screen.

The screen copper plate having the thickness of 1.3 mm also obtained a residual deformation. Its corner bending and the console part, located outside of the cardboard substrate, bending did occur.

The measurement of the geometry of the discs used before in the experiments with two counterrotating discs showed that the height of their domes was approximately 3 mm, i.e. the bending arrowhead was approximately 2.1 mm. The obtained results are the additional evidence of the considerable value of the mass-dynamic interaction force.

V. Mass-dynamic force interaction to the moveable screens

Overall view and basic diagram of experimental tool in vacuum chamber are showed in Fig 6, 7.

The disc (1) and movable screens (2) with the clearances with the disc were placed. The screens had the ability of free rotation in the bushes placed on the cardboard bases (3).

Screen frame "tabs" (2a) were in contact with the cardboard bases (3) (they rested on it), which excluded a mechanical contact of the screens with the disc (1).

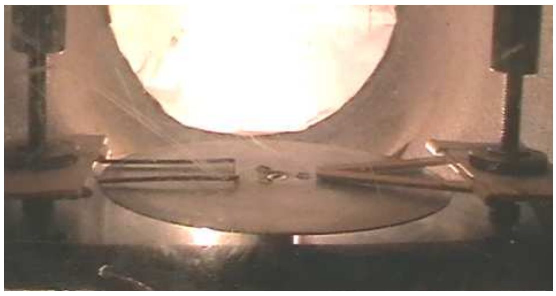
The cardboard bases (3) (pressboard with the thickness of 2.5 mm) also allowed to suppress microoscillations, which could be transferred to the rocker and correspondingly to the screen from the working electric motor and rotating imbalanced disc. Additionally, a resilient bounce of the screen from the base during their contact in the process of collision was almost excluded due to damping properties of the cardboard.

The cardboard bases (3) were able to move along spiral columns of the gage, which allowed placing the screens at different distances from the disc with their rigid fixturing. Since the gage itself was placed in thrust in the thick-walled (15 mm) and heavy vacuum chamber it almost excluded the vibration transfer from electric motor through the steel plate of the gage base to its pillars and then to the frames (screens).

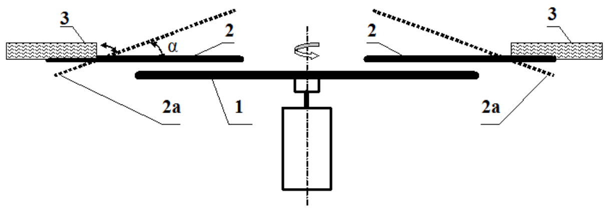
Initially, two screens were placed above the disc simultaneously (Fig. 6). The first screen (rectangular frame) was made of bimetallic steel-copper wire with the diameter of 2.4 mm. The second screen (triangular frame) was glued of wooden plates with the width of 10 mm and the thickness of 2 mm.

The wire frame was placed with a clearance of 2 mm with the disc while the wooden frame was placed with a clearance of approximately 3.5 mm.

The clearances are given approximately, because the disc had initial axial runout of about 1.5 mm which fell with the increase of velocity owing to the great centrifugal force effect and its relatively small rigidity (disc thickness was 0.9 mm).



(a)



(b)

Figure 6. Overall view in vacuum chamber (a) and basic diagram (b) of experimental tool with horizontal screens: 1 – rotating disc, 2 – movable screens (2a – screen frame backing sections "tabs"), 3 – cardboard bases.

Initially, vacuum pumping was carried out with a vacuum forepump up to residual pressure 0.1 Torr. While feeding voltage (30 V) was supplied and the disc was rotated up to 100...120 1/s continuous cyclic vibration of the wire frame was observed at first, as it was placed closer to the disc. The deviation angle of the frame was approximately $\alpha = 20°...30°$, the vibration frequency was approximately 4...5 1/s. The vibration of the lighter wooden frame which was placed further from the disc occurred only intermittently. Its deviation angle was up to $\alpha = 30°...40°$.

Thereupon without opening the chamber and resetting the gage the air pumping was carried out with an oil-vapor pump up to residual pressure (0.001 Torr). As the experiments showed, the intensity of the mass-variational (quadrupole) radiation force effect of the disc on the screens considerably increased. Continuous vibration was excited in both wire frame and wooden frame [7].

The deviation angle of the wooden frame was up to $70°\ldots80°$. The deviation angle of the wire frame was

[7] See http://www.youtube.com/watch?v=3XF0gCaoqTM.

approximately 45°. The greater value of the deviation angle of the wire frame was constructively impossible owing to the frame "tab" contact with the steel plate of the gage.

In our second series of experiments the wire frame was placed with a clearance of 3 mm to the disc with a constant setting of the gage and constant electric motor feeding voltage (U=30 V), but with 3 different vacuum values in the chamber: 0.1, 0.01 and 0.001 Torr.

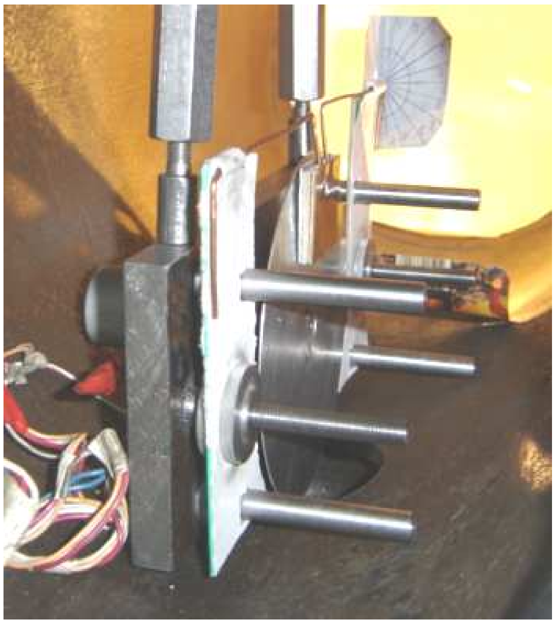
As the experiments showed, with the residual pressure in the vacuum chamber P=0.1 Torr, the wire frame repulsion did not occur. When P=0.01 Torr the frame repulsion was excited with a small deviation angle $\alpha = 10° \ldots 20°$, when P=0.001 Torr the repulsion intensity attained the greatest value limited by the "tabs" of the frame. The vibration frequency of the wire frame was approximately 6...10 1/s. Thereby, the intensification of mass-dynamic and mass-variational (quadrupole) radiation force effects with the increase of the vacuum depth in the examined range (from 0.1 up to 0.001 Torr) were ascertained.

In our third series of experiments both vacuum depth and the distance from the disc varied. The experiments showed that when the vacuum depth was increased from 0.1 up to 0.001 Torr, the distance, at which the wire frame repulsion was observed, increased approximately twice from 1.5...2 up to 3.5...4 mm, under other equal conditions (i.e. constant frequency of the disc gyration and constant value of its moment imbalance).

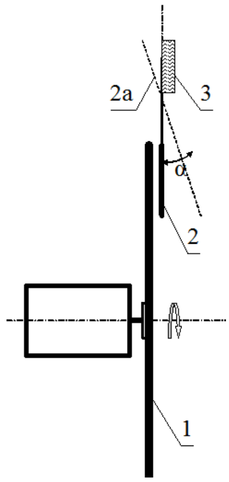
When both wire and wooden frames were placed at the distance of more than 5 mm from the disc with gyration frequency was 100...120 1/s, the wire frame repulsion was not observed even with P=0.001 Torr.

The objective of our next series of experiments was to reveal the impact of the gyrating disc axis spatial orientation and the screen plane location on the process of their non-contact force interaction in moderate vacuum – the vertical screen (Fig. 7). The disc gyration axis was horizontal while the screen was suspended vertically on the wire frame at the distance of 1.5...2 mm from the screen plane.

The screen dimensions in the diagram are 50x40 mm, the mass is 16.5 g. The screen (2) is removable – it is placed and removed from wire framework of the rocker (3), which allowed changing the screen plate material faced to the disc. In the opposite sides of the screen on its base the plates from different materials were fixed. The first plate was made of copper with the thickness of 0.3 mm while the second one was made of aluminum with the thickness of 1.3 mm.



(a)



(b)

Figure 7. Overall view in vacuum chamber (a) and basic diagram (b) of experimental tool with vertical screen: 1 – rotating disc, 2 – movable screens (2a – screen frame backing sections "tabs"), 3 – cardboard bases.

As our experiments showed, when the feeding voltage (U = 25 V) was supplied to the electric motor and the disc began to rotate (140...160 1/s) a cyclic deviation of the screen from the disc was observed. The periodical rotary angle of the wire frame was approximately $\alpha = 30° \ldots 45°$. When the increased feeding voltage (up to U = 35 V) was supplied to the electric motor the repulsion angle of the screen increased up to $\alpha = 60° \ldots 75°$[8].

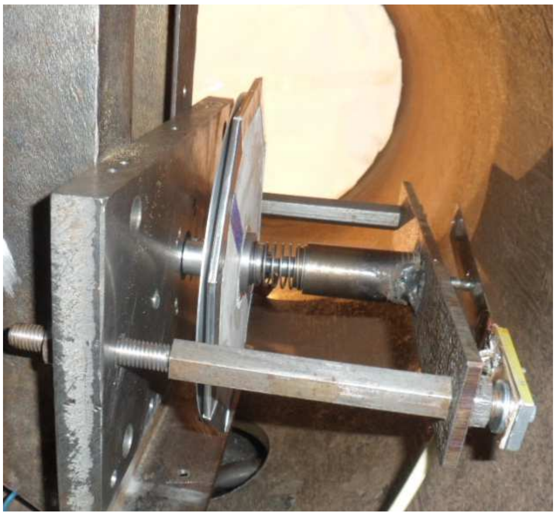
Thereby, it was experimentally ascertained that the rotating disc force effect on the screen occurred independently of the rotating disc axis spatial orientation and the screen plane, i.e. it resulted from the mass-dynamic force effect from the rotating dynamically imbalanced disc.

VI. Mass-dynamic force effect on the rigid movable screen

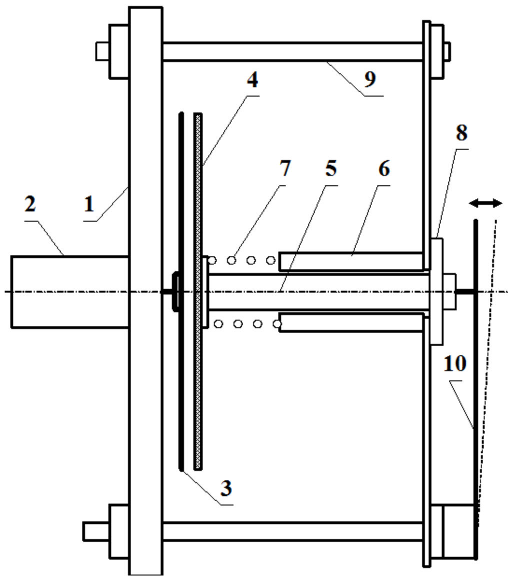
In our next series of experiments we measured the mass dynamic force effect on the rigid movable screen from the rotating dynamically imbalanced disc.

[8] See http://www.youtube.com/watch?v=exraNXii2-I.

The setup (Fig. 8) was mounted on the frame made of steel angle bars placed in thrust inside the vacuum chamber with the bolts. The steel plate (1) with the thickness of 18 mm is fixed with the bolts on the frame. The direct current electric motor D-14FT2c (2) was placed on the plate. The dynamically imbalanced disc (3) made of aluminum alloy AMg3 with the diameter 162 mm, thickness of 0.9 mm, and mass of 50 gr was placed on the electric motor axis. A flat octagonal screen (4) was placed with the adjusted clearance with the disc. The screen was made of thick cardboard with the thickness of 3 mm and it was glued with aluminum foil (0.24 mm).



(a)



(b)

Figure 8. Gage for mass-dynamic value measurement: a – overall view, b) basic diagram.

The screen and the axis (5) were able to move axially in the bush. The value of initial spring squeeze (7) was set with an adjusting screw (8) with a locknut using gauging relation obtained before.

The initial distance from the screen to the disc was set with the adjusting bar (9). The setup was supplied by a movement strain gauge (10) – resilient console-pinched plate with four strain gauges and adjusted backstop. The indication from the strain gauges when the plate bent (owing to the screen axial movement) was given to the strain-gauge station with a numeric millivoltmeter. A preliminary gauging of the strain gauge was carried out and we obtained the following:

1) dependence registered by the strain-gauge station strain on the value of the screen axial movement (the gauging was carried out with the use of the detecting head);

2) dependence of the strain on the force value affecting the screen which is necessary to repel the screen (using a mechanical dynamometer, its spring gauging had been carried out with the help of МИП-1 before).

The force value during the screen axial movement was comprised of the force necessary for the spring squeeze (7) taking into consideration its preliminary squeeze (it was set as 2 N), the force necessary for the resilient bend of the displacement sensor plate and friction forces between the axis and the bush.

Initially the experiments were carried out with the vacuum depth of 0.1 Torr. The initial clearance between the disc and the screen was set as approximately 3 mm, which securely excluded their mechanical contact. Under the feeding voltage of 30 V and after the disc began to rotate with up to 100...150 1/s the strain gauge indicated the screen repulsion from the disc (displacement from the initial location) to the distance of approximately 1...1.5 mm. As the force of the initial spring squeeze equaled 2 N, then taking into consideration gauging dependences, the repulsion force – mass dynamic force affecting the screen was in that case approximately 2.2...2.5 N.

Under the feeding voltage of 30 V and after the disc began to rotate with up to 100...150 1/s the disc forced rotation with the frequency of approximately 0.5...1.0 1/s was also excited.

The effect of the screen forced rotation during non-contact mass-dynamic interaction with the rotating dynamically imbalanced disc was similar to that which had been observed during the interaction of the discs. The induced torque in the screen material was sufficient for overcoming the friction force in the axis, the bush and the friction force which was produced by preliminary squeezed spring in the rotating and non-rotating parts of the experimental gage being in contact.

During the air filling into the vacuum chamber to obtain atmospheric pressure without opening the chamber and resetting the gage with the same electric motor feeding voltage the force effects on the screen with the rotating disc did not occur.

Then without resetting the gage the air pumping in the chamber was carried out up to 0.0008 Torr. With feeding voltage of 30 V after the beginning of the disc rotation up to 100...150 1/s the displacement strain gauge indicated the screen repulsion from the disc to the distance of approximately 1.5...2 mm. mas- dynamic force effect on the screen in that case equaled approximately 2.5...2.7 N. The forced rotation frequency increased up to 2...3 1/s [9].

The obtained results confirm that which was ascertained before, namely with the increase of the vacuum depth the mass-dynamic interaction value of the disc and the screen increase.

In order to measure the torque rotation, the same experimental gage was used, but the displacement strain gauge (10) was fixed on the gage frame in such a way that its resilient plate was in contact with a dowel (11) which was rigidly fastened with the screen (4) (Fig. 9).

During the screen turn (rotation), the torque excited by the mass-dynamic interaction was defined taking into consideration the bend value of the displacement strain gauge and the moment arm value.

The electric motor feeding voltage and the geometrical clearance between the disc and the screen remained the same (30 V and 3 mm correspondingly). As our experiments showed, under the residual pressure in the chamber of 0.1 Torr the torque value causing the screen forced rotation resulting from the mass-dynamic force effects was approximately 0.5 N·cm. Under the residual pressure in the chamber of 0.001 Torr the torque value was approximately 1 N·cm.

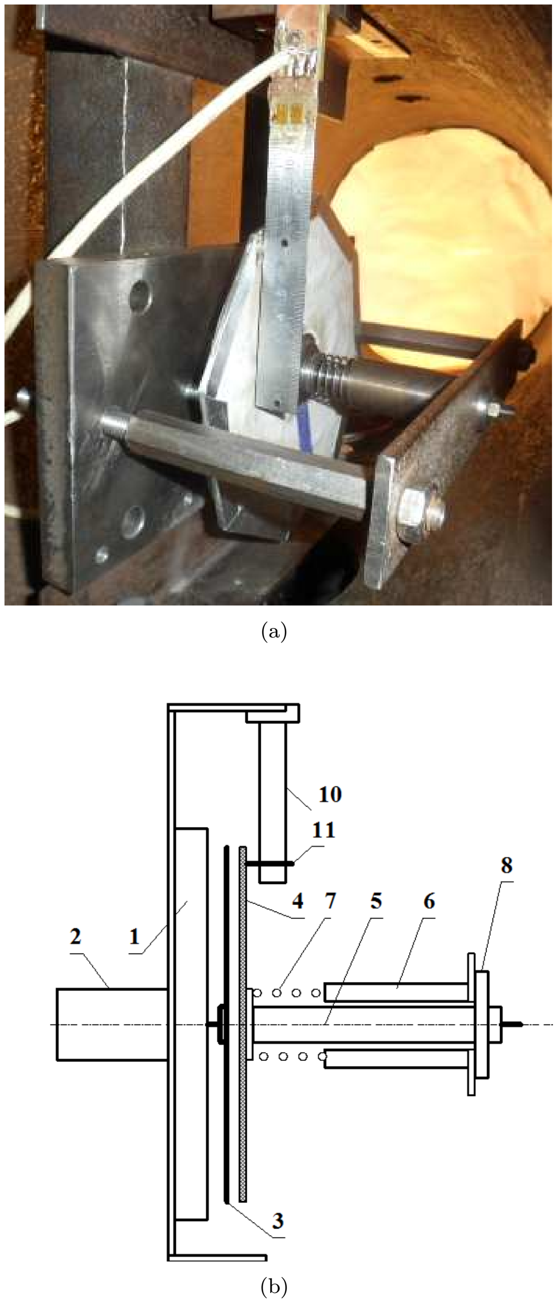


Figure 9. Gage for measurement of mass-dynamic torque value: a – overall view, b – basic diagram.

VII. The explanation of force mass-dynamic interaction mechanisms

The results obtained experimentally testify that mass-dynamic forces and mass-variational (quadrupole) radiation affects any material objects irrespective of their electric properties (copper and wood). The mass-dynamic force effect has volume nature similar to the electromagnetic force effect.

The mechanism of the disc mass-dynamic effect (in moderate vacuum) on the screen is as follows. During the rotation of dynamically imbalanced disc each point on its surface and each elemental unit of the disc material rotates on its own circumference ($R_i = const$), i.e. they do not have their axial movement and, correspondingly, axial acceleration. However, as far as any optional point of the space is concerned with the test mass m_T (point A, Fig. 10) which is motionless relative to the disc mass center, a cyclic approach and drawing of the disc surface (disc mass m_D) determined by the disc rotation frequency ω and the value of its axial runout ΔL take place (Fig. 10).

When there is a test mass in point A, accelerated movement of the disc mass m_D relative to the test mass m_T takes place. In other words one should not consider the acceleration applied to the mass (as in Newton's Laws), but they should consider the acceleration of alteration of the distance (location in the space) between masses.

Thereby, dynamical (torque) imbalance during the disc rotation (variable quadrupole moment) causes a relative

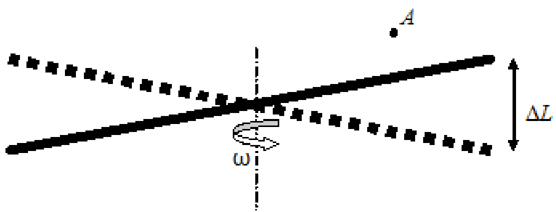


Figure 10. Relative accelerated movement of rotating dynamically imbalanced disc.

[9] Cм. http://www.youtube.com/watch?v=NZaZIKiUEZo.

accelerated movement of its mass relative to closely located masses (air molecules, screens) which excites mass-variational field, creating a mass-dynamic (spin) polarization of the matter (residual gas medium molecules, screen material molecules).

Mass-dynamic (spin) polarization of the screen material is a vector orientation of the orbital moment of the atomic (molecular) thermal momentum of the screen material and also atom spins relative to lines of force of the rotating disc mass-dynamic field (mechanical spin polarization). The necessary conditions for that are mass dynamic field (disc rotation) and mass-variational (quadrupole) radiation effect (disc dynamic imbalance). The consequence of that is the occurrence of force mass-dynamic interaction of the rotating dynamically imbalanced disc and the screens (discs, torsional pendulums, etc.).

A. The mechanism of the screen repulsion force occurrence

As one can see in the video record of the process, the screen repulsion begins with a kind of delay after the disc begins to rotate. But then the repulsion continues even with considerable decrease of the disc rotation frequency. This can be explained at first by a delay of the screen material mass-dynamic polarization during the disc rotation and then by preservation of the residual polarization of the screen material during a period of time when the disc rotation frequency falls.

Qualitatively, the process of mass-dynamic force effect on the frames made of different materials was the same. But herewith, the repulsion of the heavier wire frame always started earlier than that of the wooden frame (during the disc rotation), but it also stopped considerably quicker with the disc rotation frequency decrease. When the frames were placed at the same distance from the disc, the force effect on the wire steel-copper frame was evident to a greater extent (the greater frequency of vibration) than on the wooden frame. It is likely to be determined by different speed and degree of the mass-dynamic polarization of the materials with different density (in this case – copper and wood).

Vibrational nature of the screen repulsion process under constant disc rotation frequency is determined by a greater mass-dynamic force gradient – strong dependence of forces on the distance from the disc and by the decrease of normal constituent of the active mass-dynamic force as the angle between the screen and the disc increase.

Initially, when mass-dynamic forces reached the value exceeding the screen weight, its repulsion from the disc starts, and then owing to the impulse nature of the force, the screen (frame) passes the part of its trajectory under its own inertia. Thereafter, under the effect of gravitational forces (and also "tab" repulsion from the gage plate – with the wire frame) the screen moves back to the disc, obtains a new impulse, and, thus, the vibration process occurs.

B. The mechanism of the screen rotation excitation

Mass-variational (quadrupole) radiation effect of the rotating dynamically imbalanced disc and its mass-dynamic field resulted in spin polarization of the screen material. This causes a unidirectional molecule (atom) rotation relative to the lines of force of the mass-dynamic field (their spin orientation).

Excitation ot the molecule (atom) spin orientation as mass-dynamic polarization of the matter results in the fact that according to conservation of angular momentum the whole material object comprised of these atoms, e.g. the driven disc, comes to forced rotation opposite in direction coinciding with the rotary direction of the rotating mass which created a variable mass-dynamic (i.e. mass-variational) field. In this way the driven disc or screen forced rotation is excited with the rotation of the driving dynamically imbalanced disc.

The occurrence of the mass-dynamic field created by a well-balanced rotating disc without mass-variational radiation does not cause spin polarization. This explains why experimentally ascertained force interaction effects occur only with the rotation of the dynamically imbalanced disc (with a variable quadrupole moment) and they disappear with the rotation of the disc not having a dynamic imbalance.

A cyclic nature of the mass-dynamic radiation pressure on each point of the driven disc, determined by the driving disc rotation frequency, causes the vibration of the driven disc plane and the precession of its axis to the direction of the driving disc rotation (in the direction of pressure alteration on it, determined by the driving disc rotation). The intensity of mass-variational radiation is relatively small; therefore, as a result of molecule (atom) "pumping" of the disc by the energy of the mass-variational radiation, the process of polarization is prolonged in time. This partly determines the observed experiments delay of the screen forced rotation excitation beginning relative to the disc rotation beginning.

VIII. The analysis of the alternative explanations of observed effects

Discussing the results of the earlier research carried three possible causes to explain the physics of the processes, observed in the experiments: 1) electromagnetic nature effects; 2) the impact of residual air medium; 3) the vibration transferred from the electric motor and the rotating disc.

1) The attempt to check the occurrence of electric field near the disc butt ends during their rotation in carried-out experiments with above-mentioned frequencies of rotation, and with the use of a primitive electroscope, gives negative result. Placement of a magnetic compass, responding to quite a weak magnetic field of the Earth, close to the discs indicated the absence of the noticeable magnetic field, excited by the disc rotation and their interaction. The intensity of varying magnetic field close to the butt ends and the disc planes were measured with the inductive sensor (150 turns, the winding diameter – 8 mm, the length – 16 mm), connected to Mastech MY-62 multimeter (with the range – 0 – 200 mV). The measurement indicated the absence of induced voltage in the inductive sensor

during the disc spinup, their vibrations, and interaction, i.e. a alternating magnetic field in the process of the disc interaction under study was not excited (within the measurement precision).

These results completely correspond to the results of the experiments, carried out by P.N. Lebedev (1911), the aim of which was the detection of magnetic field occurrence during high-speed rotation of the electroconductive ring caused by "centrifugal polarization". With the copper ring rotated at the velocity up to 5000 - 6000 1/s, he failed to record the occurrence of rotating ring magnetic field. Later attempts of American physicists (Rigel I.J., 1970r.), trying to repeat those experiments, having increased the equipment sensitivity, also did not result in detection of expected effect. The most precise experiments were carried out by B.V. Vasilyev (Dubna, Joint Institute for Nuclear Research, 1984). Under the conditions of magnetic vacuum, a one-kilo ampoule with liquid mercury rotated with the frequency of 1 kHz. With the use of SQUIDs (superconducting quantum interference devices) there was an attempt to register magnetization of a fast rotating metal sample, but the result was negative (with the exception of parasitic inducing). This research is described in details in the overview [8].

Taking into account mentioned above the fact that force interaction exhibited between the discs, made of non-conductive materials (cardboard, paper, plastic), the observed effects do not have an electromagnetic nature.

2) Weakness of the second hypothesis about the impact of residual air medium resulting in force effect of the disc on the screen (disc, torsion pendulum), was experimentally proven. It is known that gas-dynamic phenomena with the residual pressure of 0.1 Torr almost do not appear, while the effects determined by the gas viscosity sharply decrease with increase of the vacuum depth.

At the same time, experiments carried out, showed that the force mass-dynamic interaction of the discs and screens (discs, torsion pendulums), on the contrary, increases with the increase of the vacuum depth. We explain this by the decrease of the shielding effect of the residual gas medium.

When the residual pressure is 0.001 Torr (as it was in our experiments), Loschmidt number is sufficiently great (approximately $2 \cdot 10^{14}$ molecules in 1 cm^3), and gas molecules are of the same material objects like the molecules of the matter comprising the screen (the second disc or the torsion pendulum). While interacting with variable mass-dynamic field created by the rotating dynamically imbalanced disc, gas molecules orientate their spins (thermal angular momentum, nuclear spins) are oppositely directed to outer field. This creates a shielding effect preventing mass-dynamic field propagation and decreasing its effect on the screen. Deeper the vacuum, the less the shielding effect was registered in our experiments. Naturally, the shielding effect increases with the increase of the distance from the rotating disc to the screen (disc, torsion pendulum, etc.). This results in decrease of the force interaction on the screen with the increase of the distance from the rotating dynamically imbalanced disc, which was also registered in our experiments.

This effect has an analogy with electromagnetic interaction – eddy currents induced in electroconductive screen by outer variable magnetic (electromagnetic) field prevent the propagation of electromagnetic field into the depth of material (skin layer, with the depth depending on material electroconductivity and electromagnetic field frequency).

3) The weakness of the third hypothesis that vibration effect excited by the rotation of dynamically imbalance disc is the cause of force interaction occurrence in the experiments is also obvious.

Firstly, a great mass of the thick-walled vacuum chamber and a massive experimental tool rigidly fixed in it (the total mass is more than 50 kg while the rotating disc mass is 50 gr) almost excludes vibration occurrence. Mechanical oscillation (vibration) of the experimental tool itself in our carried out experiments were not observed.

Secondly and the most important, a great dependence of the observed force interaction in the distance between the disc and the screen was experimentally registered.

A slight alteration of the distance between the disc and the screen (by a few millimeters) resulted in sharp fall, and then to a termination of their force interaction (the screen repulsion and its forced rotation). This appeared in experiments with different design, geometry, mass and dimensions of the experimental tool. Such a slight alteration of mechanical system parameters – a slight displacement of the small screen mass (or the second disc) can never result in such an alteration of the system vibrational properties to cause such a great (quantitative and qualitative) alteration of the observed processes nature.

Furthermore, one cannot in principle explain the following experimentally ascertained force interaction effects:

- "blowing" and repulsion of the screen made of foil and film or repulsion of the rigid screen from the disc with a force of approximately 2.5...2.7 N, which was mentioned above;

- flexural wave excitation and "flowing" each other of the discs rotating in opposite direction or flexural wave excitation on the disc with a rigid placement of a small screen, which was mentioned above;

- forced rotation excitation of the second disc for the stopping of which it is necessary to supply the second electric motor with "counter" voltage comparable with electric motor feeding voltage of the first disc or excitation of torque, rotating the screen, with the value of approximately 1 N·cm, which was mentioned above.

IX. Force mass-dynamic interaction manifestations in nature

In carried-out experiments its shielding and masking effect of gas medium falls as result of its density decrease during vacuumizating. As a result, physical processes caused by the force mass-dynamic interaction and mass-variational radiation start to become clearly apparent. In examined processes force mass-dynamic interaction is observed when the distance is about millimeters. A sharp rise of the force interaction value with the decrease of the distance between interacting objects (disc, screen) is experimentally ascertained.

A similar interaction, obviously, will take place during any reciprocal relative accelerated mass motions. Force mass-dynamic interaction is manifested in the most dramatic way during gas and liquid mediums motion. Owing to a small distance between interacting molecules of these mediums great mass-dynamic forces appear, which generate (if there is energy inflow) vortical processes (tornado, swirl and so forth) or e.g. short-period low tide or high tide phenomena in the Zhiguli man-made lake [9].

Gravitational waves (they represent mass-variational radiation) from space are not registered on the Earth surface as they are screened (dissipated) by the Earth atmosphere similar to that in our experiments even a residual air medium screened mass-variational (quadrupole) radiation of the dynamically rotating imbalanced masses.

Electromagnetic interaction caused by the electric charge of particles or bodies, in particular cases are considered as: a) electric field, b) magnetic field, c) electromagnetic radiation. Similar to that mass-dynamic interaction determined by the relative spatial location and relative motion of particle masses or body masses in particular cases are considered as: a) gravitational field, b) mass-dynamic field, c) mass-variational (quadrupole) radiation – gravitational waves.

Mass-dynamic interaction is manifested as a matter spin polarization and material body (mass) rotation excitation with their relative motion.

The main observable type of material body motion in nature is their rotation round their own axes (planets, stars) or round the central body (planet systems and so forth). One could assume that the cause of rotation of these bodies and systems is force mass-dynamic interaction of individual particles of the matter which was manifested during their formation in the process of their relative motion under the influence of gravitational forces.

X. Conclusion

We experimentally ascertained non-electromagnetic force interaction, exhibiting itself during rotation in vacuum discs with variable quadrupole moment (dynamic imbalance), affecting moving masses (screens).

The rotating disc rotation speed in our experiments was 100 – 180 1/s, and the linear speed of the disc peripheral points of the disc was not more than 50 – 100 m/s. At the same time, experimentally measured mass-dynamic force, affecting the screen from the rotating dynamically imbalanced disc, weighing 50 g, was approximately 2.5...2.7 H, while the value of mass-dynamic torsion torque was 1 N·cm. That was by 20 orders more than the value of gravimagnetic forces, which would have placed in this case according to general relativity theory.

The manifestation of described above sufficiently great effects of force interaction show that there is a type of interaction in nature determined by a relative motion of mass similar to that which takes place during a relative motion of electric charges.

In statics it is known as gravitational attraction of masses. In dynamics during a relative motion it is mass rotation excitation, repulsion or attraction of rotating masses – depending on relative orientation of their angular momentum. During relative accelerated motion of masses this is excitation of mass-variational (quadrupole) radiation.

References

[1] Physical encyclopedia. vol. 5 / ed. a.m. prokhorov. - m: Great russian encyclopedia, 1998. - 691p.

[2] Myshkin N.P. Motion of body in flow of radiating power (in russian). *Journal of Russian Physical-Chemical Society*, (43), 1906.

[3] Kozyrev N.A. On the possibility of experimental investigation of the properties of time. *Time in Science and Philosopy. Praga*, pages 111–132, 1971.

[4] Godin S.M. Roshchin V, V. Experimental research of non-linear effects in dynamical magnetic system (in russian). *http://n-t.ru/tp/ts/dms.htm*, 2001.

[5] Plotnikov S.V. Interaction of rotating masses (in russian). *http://ntpo.com/physics/studies/22.shtml*.

[6] Samokhvalov V.N. Experimental evidences of mass-dynamical fields and forces (in russian). *Fundamental problems of science and technology. Proceedings of the International Scientific Congress*, (33/2):488–497, 2008.

[7] Samokhvalov V.N. Mass-dynamic and mass-variational interaction of moving bodies (in russian). *Reports of independent authors, Israel*, (13):110–159, 2009.

[8] Azad R. On the problem of the appearance of a magnetic field in rotating objects (brief review of papers) (in russian). *Vestnik RUDN, Physics*, (9):20–26, 2001.

[9] Samokhvalov V.N. Investigation of the influence of the earth's vortex gravitational field on the motion of air and water masses (in russian). *Proceedings of the International Forum on Science, Technology and Education, Vol. 3 / ed. V.A. Malinnikova, V.V. Vishnevsky. - M .: Academy of Earth Sciences*, pages 40–41, 2008.