BUCKET EXPERIMENT RE-VISITED

According to 'MATTER (Re-examined)'

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Abstract: Isaac Newton's 'bucket argument' was designed to show that true rotational motion could be defined only with respect to absolute space and not with respect to surrounding macrobodies, whatever states of motion they have. Even if the whole universe (surrounding a bucket of water on Earth's surface) rotates about it, the water's surface in the bucket will remain flat, unless the bucket itself has a true spin motion with respect to an absolute reference. Further mathematical analysis pointed towards a real action by an imaginary 'centrifugal force'. It is not logical for imaginary efforts to cause real action. Analysing actions of 3D matter-particles of water (in a rotating bucket in a universal medium) by additional work associated with them (instead of the equilibrium of 'forces' on it) can give a logical explanation of actions, without using imaginary 'centrifugal force'. All conclusions expressed in this article are from the book, 'MATTER (Re-examined)' [1]. For details, kindly refer to the same.

Keywords: 'Centrifugal force', Centripetal effort, Bucket argument.

For the time being, we may neglect the container and use the rotary motion of a fluid macrobody for discussion. Intrinsic work about a macrobody creates and develops its constituent 3D matter-particles and sustains its integrity and stability. Its state of motion depends on additional work associated with its matter-field. Motions of 3D matter-particles may represent additional work, associated with each action on/about the fluid macrobody. In this article, we may neglect the intrinsic part of total work, associated with the fluid macrobody (required for the development, stability and integrity of the macrobody) and consider only the additional work, which is responsible for its motions and deformations, as the sole work associated with the macrobody. Since 'force' is a mathematical relation between work and displacement, in this article, work is represented by the motion in direction and magnitude. The direction of instantaneous motion of a 3D matter-particle, in a rotating macrobody, is deflected away from the tangent to the circular path. If the rotating macrobody is fluid (or solid of lower viscosity), inertial actions tend to spread its material content radially, in the plane of its rotation. 3D matter-particles, attempting to move away from the centre point, are resisted by cohesive efforts (centripetal efforts) within the macrobody. Magnitudes of radial motion of 3D matter-particles are proportional to their (derived) tangential speed. A fluid macrobody has low rigidity, and its 3D matter-particles are free, up to an extent permitted by the viscosity of the fluid, to move in relation to its neighbours. 3D matter-particles nearer to the point of action of an external effort usually move faster than others situated away from the point of action of an external effort. 3D matter-particles, at the point of action of an external effort, are moved directly by the mechanism of action, and others are pulled along with faster-moving 3D matter-particles by adhesion between them. Hence, the (derived) tangential speed of 3D matter-particles in rotating fluid macrobody need not always be in proportion to its distance from the point of application of external effort. If a fluid macrobody (rotating in a plane parallel to its surface - horizontal plane) is on/near the surface of a larger macrobody, it is under the influence of gravitational attraction towards the larger macrobody, in addition to the inertial actions about it. Gravitational attraction on the fluid macrobody's 3D matter-particles tends to move them towards the larger macrobody, in a direction perpendicular to their motion in circular paths. Now, each 3D matter-particle of the rotating fluid macrobody is under two independent motions.

They are:

(1) Angular motion in the horizontal plane, about the centre of rotation, resolved into two components:

a) Angular motion about the centre of rotation, tangential to the curved path.

b) Linear outward motion, away from the centre of rotation, in the plane of rotation. (We shall consider this component when the fluid macrobody in a container is considered)

(2) Linear motion in the vertical plane, towards the larger macrobody, due to gravitational attraction.

If 3D matter-particles of fluid macrobody were free to move towards the larger macrobody, magnitudes of vertical displacement, due to gravitational attraction, would have been equal on all of its 3D matter-particles. Hence, the work invested in and about each of them in the downward direction is equal in magnitude. This is because the magnitudes of acceleration due to gravitational attraction are equal on all of them.

Magnitudes of additional work (rate of displacement) in the horizontal plane, due to rotational motion, are proportional to the angular speeds of 3D matter-particles. Resultant directions and magnitudes of work about them depend on their angular speeds. Greater angular speed of a 3D matter-particle reduces its rate of displacement towards the larger macrobody, due to gravitational attraction. Lower angular speed of a 3D matter-particle increases its rate of displacement towards the larger macrobody, due to gravitational attraction.

If the fluid macrobody is in a container (in a static state), its 3D matter-particles cannot be displaced towards the larger macrobody. However, in a spinning fluid macrobody, changes in the magnitudes of work associated with 3D matter-particles (actions equivalent to the magnitudes of possible displacement) can make changes in their locations relative to each other. Relative positions of 3D matter-particles, situated along radial lines on the surface of the fluid macrobody, determine the shape of its upper surface.

If rotating effort (torque) is applied near the periphery of the fluid macrobody (like, liquid kept in a spinning container) placed on the surface of another larger macrobody, 3D matter-particles nearer to its periphery have greater angular speed compared to the 3D matter-particles nearer to its centre of rotation. Consequently, 3D matter-particles near the periphery have lesser resultant additional work/displacement towards the larger macrobody compared to the resultant additional work/displacement of 3D matter-particles near the centre of rotation. The difference in magnitudes of resultant additional work, shown by probable displacements, corresponding to the additional work, creates variation in compression experienced at different parts of the fluid macrobody. The rotating fluid macrobody has lower downward pressure near its periphery and higher downward pressure near its centre of rotation. In order to reach an equilibrium state, the fluid macrobody's upper surface (away from the larger macrobody) assumes a concave shape. Surface of fluid rotating macrobody, near its periphery, rises above original surface level, and surface near its centre of rotation falls below original surface level, as seen in whirlpools or as seen in Newton's bucket experiment.

Figure 1 shows the surface of a fluid macrobody situated on/near the surface of a large macrobody. 'a', 'd', 'g', and 'j' are a few of its 3D matter-particles. 3D matter-particle 'j' is near the outer periphery, and others are evenly placed nearer to the centre of rotation. Let an anti-clockwise torque, acting at its periphery, rotate the fluid macrobody. Initially, its outermost layer attains angular motion. As this layer is rotated, friction between subsequent layers tends to turn the whole fluid macrobody along with the outer layer. However, due to the low viscosity of the fluid, the fluid macrobody picks up angular motion gradually. First, the outer layer near the periphery starts to rotate, and this rotary motion is gradually transferred to the inner layers. At any instant, the outermost layer has highest angular speed. Angular speeds of inner layers towards the centre of rotation gradually decrease. 'ab', 'de', 'gh' and 'jk', respectively, show magnitudes of additional work associated with 3D matter-particles, corresponding to their angular motions. Magnitudes of additional work associated with gravitational attractions on all 3D matter-particles are equal, and they are represented by arrows 'bc', 'ef', 'hi', and 'km'.

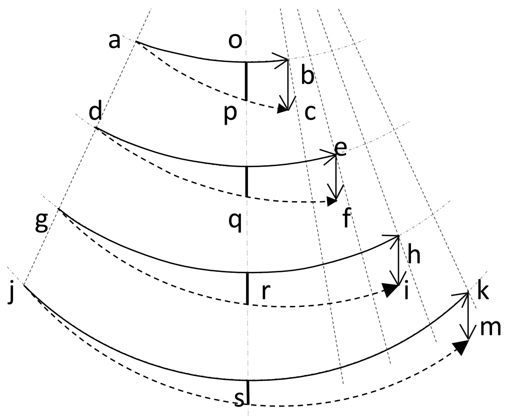

Figure 1

If 3D matter-particles were free to move downwards, their resultant motions would have corresponded to resultant additional work associated with them, along lines 'jm', 'gi', 'df', and 'ac'. Considering 3D matter-particles along a radial line (at the centre of the figure), magnitudes of resultant additional work associated with them (corresponding to probable displacements) in the downward direction are shown by lines 'p', 'q', 'r' and 's'.

Magnitude of 'p' > magnitude of 'q' > magnitude of 'r' > magnitude of 's'.

Downward deflections of 3D matter-particles' probable paths increase as their distances from the centre of rotation reduce. The tendency for unequal vertical displacements of 3D matter-particles creates internal pressure within the fluid macrobody. To reach equilibrium, the surface of the fluid macrobody assumes an appropriate curved shape. 3D matter-particles near the centre of rotation have greater downward pressure on them. 3D matter-particles farther from the centre of rotation have less downward pressure on them. 3D matter-particles near the centre of rotation are depressed by a greater magnitude to raise 3D matter-particles near the outer periphery and form a concave shape of the surface of the fluid macrobody.

Figure 2 shows part of the surface cross-section with its left-hand side towards the centre of rotation. XX is a radial line on surface, when fluid macro body is not spinning. 'p', 'q', 'r' and 's' shows probable depth to which its surface could be depressed due to rotary motion. Curved dotted line 'yy' shows the shape of the surface when the fluid macrobody is spinning. Since the volume of fluid macrobody is the same, its surface on one side of the centre of rotation reaches the resultant level as shown by the curved line, YY. The right-hand side of the figure is towards the periphery, and the left-hand side of the figure is towards the centre of rotation. Surface near the periphery rises, and the surface near the centre of rotation falls to create a concave surface.

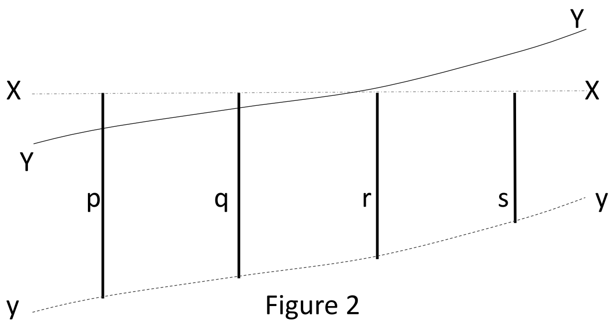

Figure 2

If a fluid macrobody is in a container, its relative motion with respect to the container is bound to cause additional efforts on it. Let us consider water in a bucket situated on Earth. When the bucket is in a steady state of motion with respect to the earth, the surface of water in it may be considered flat. As the bucket starts to spin, friction between the bucket and water initiates the spin motion of water. The rotational speed of water towards the centre of rotation diminishes gradually. The difference in angular speeds of 3D matter-particles in water causes the surface of water to form a concave shape as explained above.

In addition, as the fluid macrobody is contained, free motion of its 3D matter-particles is restricted within the container. The container restricts the outward motion of 3D matter-particles in the horizontal plane. The container exerts a reaction on them to neutralise their outward component of angular motion. This centripetal effort is real, and hence it does additional work. Additional work, introduced by the centripetal effort, neutralises a certain part of the additional work associated with the angular motion of the 3D matter-particles in the horizontal plane. Reduction in outward additional work due to rotary motion, by the additional work due to centripetal effort, not only compensates for the removal of outward displacements of 3D matter-particles but also displaces them inward, towards the centre of rotation, to maintain steady curvatures of their paths.

A rigid container restricts the periphery of a rotating fluid macrobody. The outward-moving tendency of the 3D matter-particles tend to press on the container wall and thus increase compression in the fluid near the container wall. The magnitude of compression is related to the angular speed of 3D matter-particles. 3D matter-particles near the periphery experience greater compression, and 3D matter-particles near the centre of rotation experience lesser compression. To reach equilibrium, the fluid surface near and towards the container wall rises and curves the surface of the fluid macrobody into a concave shape. This curvature is in addition to the concave curvature formed by the rotary motion of the fluid macrobody. This action, in non-inertial reference frame, refers to a 'reaction' to centripetal effort, applied by the container, to restrict the outward motion of 3D matter-particles of fluid macrobody.

From the above explanations, it can be seen that the concave shape of the fluid surface, obtained during the 'bucket experiment' is due to the differences in rotational speeds of 3D matter-particles and internal compression caused by the centripetal effort provided by the rigid container. These are the real causes of changes in the shape of fluid surface in the bucket experiments, rather than assumed 'real actions' by the fictitious 'centrifugal force'.

If rotating effort (torque) is applied near the centre of the fluid macrobody (like the fluid body is spun by an impeller at its centre), placed on the surface of another larger macrobody, 3D matter-particles near the periphery of the fluid macrobody have a lower angular speed compared to the 3D matter-particles near its centre of rotation. The rotational speed of the fluid macrobody towards the periphery diminishes gradually. Consequently, 3D matter-particles near the periphery have greater resultant additional work (probable displacement) towards the larger macrobody compared to the resultant additional work (probable displacement) of 3D matter-particles near the centre of rotation of the fluid macrobody. The difference in the magnitudes of resultant additional work creates variation in compression experienced at different parts of the fluid macrobody. The rotating fluid macrobody has greater compression near its periphery and lower compression near the centre of its rotation. To reach equilibrium, the fluid macrobody's upper surface (away from the larger macrobody) assumes a convex shape. The surface of the rotating fluid macrobody near its centre rises above the surface near the periphery, as seen in cyclones. The tendency of the central region to rise enhances any other lifting efforts present in the central part of the fluid macrobody.

Figure 3 shows surface of fluid macrobody in a container, situated on/near surface of a large macrobody. 'a', 'd', 'g' and 'j' are few 3D matter-particles of fluid macrobody. 3D matter-particle 'j' is near the outer periphery, and others are evenly placed nearer to the centre of rotation. The fluid macrobody is being rotated in an anti-clockwise direction by an impeller at its centre. As the impeller rotates, it tends to turn the fluid macrobody along with it. However, due to the low viscosity of the fluid, it picks up angular motion gradually. First, the layers near the centre start to rotate, and this rotary motion is transferred gradually to the outer layers. At any instant, the innermost layer has the highest angular speed. Angular speeds of outer layers towards the periphery gradually decrease. ‘ab’, ‘de’, ‘gh’ and ‘jk’, respectively, show the magnitudes of additional work associated with 3D matter-particles, corresponding to their angular motions. Magnitudes of additional works associated with gravitational attractions on all 3D matter-particles are equal, and they are represented by ‘bc’, ‘ef’, ‘hi’ and ‘km’.

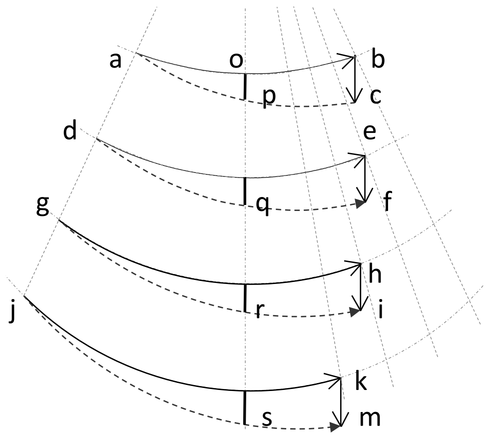

Figure 3

If 3D matter-particles were free to move downwards, their resultant motions would have corresponded to resultant additional work associated with them, along lines ‘jm’, ‘gi’, ‘df’ and ‘ac’. Considering 3D matter-particles along a radial line (at the centre of the figure), magnitudes of resultant additional work associated with them (corresponding to probable displacements) in a downward direction are shown by lines ‘p’, ‘q’, ‘r’ and ‘s’.

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Downward deflections of 3D matter-particles’ probable paths increase as their distances from the outer periphery reduce. The tendency for unequal vertical displacements of 3D matter-particles creates internal pressure within the fluid macrobody. To reach equilibrium, its surface assumes an appropriate curved shape. 3D matter-particles near the centre of rotation have less downward pressure on them. 3D matter-particles farther from the centre of rotation have greater downward pressure on them. 3D matter-particles near the outer periphery depress by greater magnitudes to raise 3D matter-particles near the centre of rotation and form a convex shape of its surface.

Figure 4 shows part of the surface cross-section with its left-hand side towards the centre of rotation. XX is a radial line on surface, when fluid macrobody is not spinning. ‘p’, ‘q’, ‘r’ and ‘s’ shows probable depths to which surface could be depressed. Curved dotted line ‘yy’ shows the probable surface when the fluid macrobody is spinning. Since the volume of fluid macrobody remains the same, its surface, on one side of the centre of rotation, attains resultant level as shown by the curved line, YY. The right-hand side of the figure is towards the periphery, and the left-hand side of the figure is towards the centre of rotation.

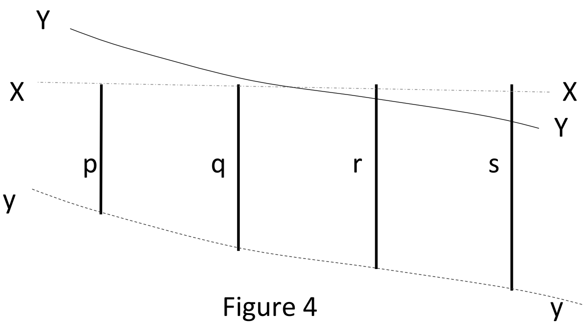

Figure 4

Consider a case where rotating effort is applied uniformly throughout the fluid macrobody. Angular speeds of all 3D matter-particles in it are equal. Fluid macrobody’s surface tends to remain flat. No curvature is formed at the surface due to gravitational attraction towards the larger macrobody. However, the outward radial component of linear motion along circular paths causes the 3D matter-particles of the fluid macrobody to spread outwards. If the rigid container restricts the outward spread of fluid macrobody, centripetal efforts, created by restriction, produce subsequent internal compression of fluid macrobody to curve its upper surface into a concave shape. If the rotating fluid macrobody in the container is situated in free space (where it is not influenced by the presence of any other large macrobody), both free surfaces (perpendicular to the plane of rotation) of the fluid macrobody tend to form concave shapes.

Conclusion:

Changes in the shape of the surface of a spinning fluid macrobody (on the surface of the Earth) are caused by gravitational attraction on its 3D matter-particles, which are moving at different angular speeds. These are augmented by changes caused by the reaction of the container to outward components of its linear motion, in circular paths. These are physical actions produced by the spin motion of the fluid macrobody with respect to an absolute reference, rather than actions by imaginary 'centrifugal forces'.

Reference:

[1] Nainan K. Varghese, *MATTER (Re-examined)*, http://www.matterdoc.in/

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