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 macro bodies, whatsoever states of motion they have. Even if whole universe (surrounding a bucket of water on earth's surface) rotates about it, water surface in bucket will remain flat, unless bucket itself has a true spin motion with respect to absolute reference. Further mathematical analysis pointed towards real action by imaginary 'centrifugal force'. It is not logical for imaginary efforts to cause real action. Analysing actions of 3D matter-particles of water (in rotating bucket in universal medium) by additional work associated with them (instead of equilibrium of 'forces' on it) can give 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 container and use rotary motion of fluid macro body for discussion. Intrinsic work about a macro body creates and develops its constituent 3D matter-particles and sustains its integrity and stability. Its state of motion depends on additional work associated with it's matter-field. Motions of 3D matter-particles may represent additional work, associated with each action on/about fluid macro body. In this article, we may neglect intrinsic part of total work, associated with fluid macro body (required for development, stability and integrity of macro body) and consider only additional work, which is responsible for its motions and deformations, as sole work associated with macro body. Since 'force' is a mathematical relation between work and displacement, in this article, work is represented by motion in direction and magnitude.

Direction of instantaneous motion of a 3D matter-particle, in a rotating macro body, is deflected away from tangent to circular path. If rotating macro body 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 center point, are resisted by cohesive efforts (centripetal efforts) within the macro body. Magnitudes of radial motion of 3D matter-particles are proportional to their (derived) tangential speed. A fluid macro body has low rigidity and its 3D matter-particles are free, up to an extent permitted by viscosity of fluid, to move in relation to its neighbours. 3D matter-particles nearer to point of action of an external effort, usually, move faster than others, situated away from point of action of external effort. 3D matter-particles, at the point of action of external effort, are moved directly by mechanism of action and others are pulled along with faster moving 3D matter-particles by adhesion between them. Hence, (derived) tangential speed of 3D matter-particles in rotating fluid macro body needs not always be in proportion to its distance from point of application of external effort.

If a fluid macro body (rotating in plane parallel to its surface - horizontal plane) is on/near surface of a larger macro body, it is under influence of gravitational attraction towards larger macro body, in addition to inertial actions about it. Gravitational attraction on fluid macro body's 3D matter-particles tends to move them towards larger macro body, in direction perpendicular to their motion in circular paths. Now, each 3D matter-particle of rotating fluid macro body is under two independent motions. They are;

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

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

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

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

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

Magnitudes of additional work (rate of displacement) in horizontal plane, due to rotational motion, are proportional to 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 larger macro body, due to gravitational attraction. Lower angular speed of a 3D matter-particle increases its rate of displacement towards larger macro body, due to gravitational attraction.

If fluid macro body is in a container (in static state), its 3D matter-particles cannot be displaced towards larger macro body. However, in a spinning fluid macro body, changes in magnitudes of work associated with 3D matter-particles (actions equivalent to 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 surface of fluid macro body determine shape of its upper surface.

If rotating effort (torque) is applied near periphery of fluid macro body (like, liquid kept in a spinning container) placed on the surface of another larger macro body, 3D matter-particles nearer to its periphery have greater angular speed compared to 3D matter-particles nearer to its centre of rotation. Consequently, 3D matter-particles near periphery have lesser resultant additional work/displacement towards larger macro body compared to resultant additional work/displacement of 3D matter-particles near centre of rotation. Difference in magnitudes of resultant additional work, shown by probable displacements, corresponding to additional work, creates variation in compression experienced at different parts of fluid macro body. Rotating fluid macro body has lower downward pressure near its periphery and higher downward pressure, near its center of rotation. In order to reach equilibrium state, fluid macro body's upper surface (away from larger macro body) assumes concave shape. Surface of fluid rotating macro body, 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 surface of a fluid macro body situated on/near surface of a large macro body. 'a', 'd', 'g' and 'j' are few of its 3D matter-particles. 3D matter-particle 'j' is near the outer periphery and others are evenly placed nearer to centre of rotation. Let an anti-clockwise torque, acting at its periphery, rotate the fluid macro body. Initially, its outermost layer attains angular motion. As this layer is rotated, friction between subsequent layers tends to turn whole of fluid macro body along with outer layer. However, due to low viscosity of fluid, fluid macro body picks up angular motion, gradually. First, outer layer near periphery starts to rotate and this rotary motion is transferred gradually to inner layers. At any instant, outermost layer has highest angular speed. Angular speeds of inner layers towards centre of rotation gradually decrease. ‘ab’, ‘de’, ‘gh’ and ‘jk’, respectively show magnitudes of additional works 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 arrows ‘bc’, ‘ef’, ‘hi’ and ‘km’.

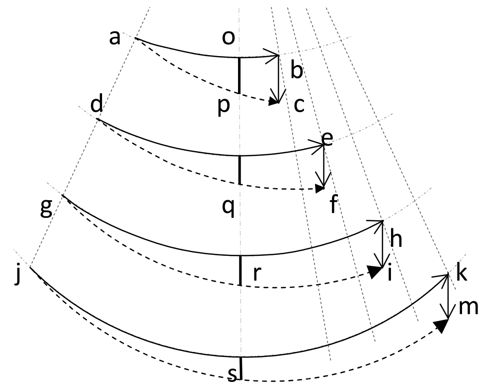

Figure 1

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 figure), magnitudes of resultant additional works associated with them (corresponding to probable displacements) in 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 centre of rotation reduce. Tendency for unequal vertical displacements of 3D matter-particles create internal pressure within the fluid macro body. To reach equilibrium, surface of the fluid macro body assumes appropriate curved shape. 3D matter-particles near centre of rotation have greater downward pressure on them. 3D matter-particles farther from centre of rotation have lesser downward pressure on them. 3D matter-particles near centre of rotation depress by greater magnitude to raise 3D matter-particles near outer periphery and form concave shape of surface of fluid macro body.

Figure 2 shows part of surface-cross section with its left-hand side towards 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 probable surface, when the fluid macro body is spinning. Since volume of fluid macro body is same, its surface on one side of centre of rotation reaches resultant level as shown by curved line, YY. Right-hand side of figure is towards periphery and left-hand side of figure is towards centre of rotation. Surface near periphery rises and surface near centre of rotation falls to create a concave surface.

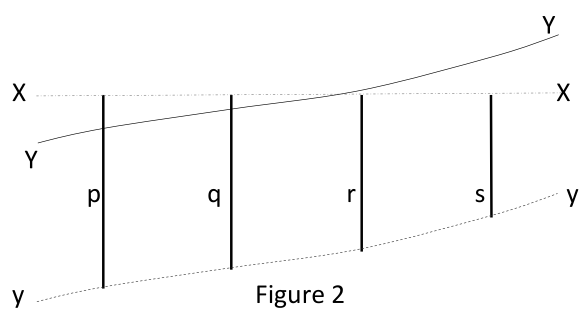

Figure 2

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

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

Rigid container restricts periphery of rotating fluid macro body. Outward moving tendency of 3D matter-particles tend to press on container-wall and thus increase compression in fluid near container-wall. Magnitude of compression is related to angular speed of 3D matter-particles. 3D matter-particles near periphery experience greater compression and 3D matter-particles near centre of rotation experience lesser compression. In order to reach equilibrium, fluid surface near and towards container-wall rises and curve surface of fluid to concave shape. This curvature is in addition to concave curvature formed by rotary motion of fluid macro body. This action, in non-inertial reference frame, refers to a 'reaction' to centripetal effort, applied by container, to restrict outward motion of 3D matter-particles of fluid macro body.

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

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

Figure 3 shows surface of fluid macro body in a container, situated on/near surface of a large macro body. 'a', 'd', 'g' and 'j' are few 3D matter-particles of fluid macro body. 3D matter-particle 'j' is near outer periphery and others are evenly placed nearer to centre of rotation. Fluid macro body is being rotated in anti-clockwise direction by an impeller at its centre. As impeller rotates, it tends to turn fluid macro body also along with it. However, due to low viscosity of fluid, it picks up angular motion, gradually. First, layers near centre start to rotate and this rotary motion is transferred gradually to its outer layers. At any instant, innermost layer has highest angular speed. Angular speeds of outer layers towards periphery gradually decrease. 'ab', 'de', 'gh' and 'jk', respectively show magnitudes of additional works 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'.

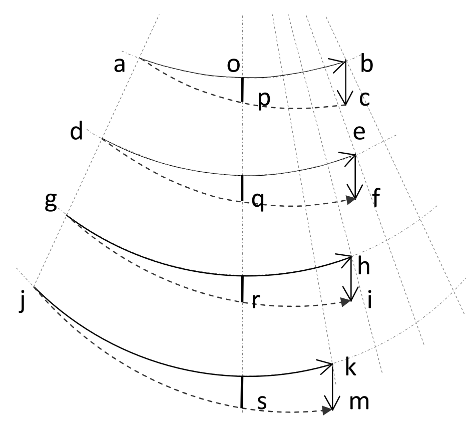

Figure 3

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 figure), magnitudes of resultant additional works associated with them (corresponding to probable displacements) in downward direction are shown by lines ‘p’, ‘q’, ‘r’ and ‘s’.

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

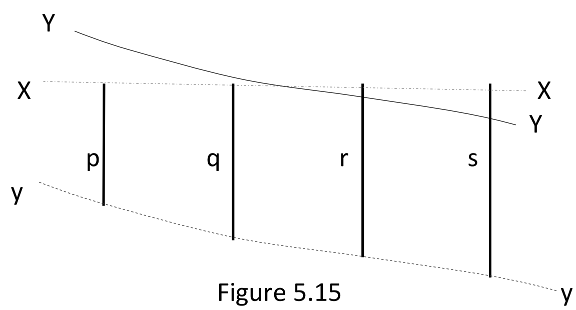

Figure 5.15

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

Conclusion:

Changes in shape of surface of a spinning fluid macro body (on surface of 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 reaction of container to outward components of their linear motion, in circular paths. These are physical actions produced by spin motion of fluid macro body with respect to absolute reference, rather that actions by imaginary ‘centrifugal forces’.

Reference:

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

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