MPEMBA EFFECT

(According to "*Hypothesis on* MATTER")

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Abstract: Two equal volumes of water, one slightly warmer than the other, when placed in similar external conditions to freeze, warmer water is noticed to freeze before the other. This phenomenon (Mpemba effect) is the result of difference in the rate of inter-atomic movements during cooling stages of macro bodies with different initial temperatures.

Keywords: Heating, Cooling, Latent stage, Mpemba effect, Hypothesis on MATTER.

Introduction:

'Hypothesis on MATTER' describes an alternative concept, which is still at its speculative stage. According to this concept; matter content and energy content of a 3D matter body are entirely separate. They support each other to maintain integrity and stability of a macro body at its current physical state and state (of motion). They are not convertible into each other.

Matter is the only real entity in nature and it provides substance to all bodies of objective existence in space. Whole matter in nature is in the form of 'quanta of matter'. Quantum of matter is the only type of entity, postulated in this concept. Diverse matter bodies and their properties are developed from inherent properties of these postulated particles.

Quanta of matter (outside 3D matter particles) form two-dimensional latticework structures, called '2D energy fields', in each spatial plane. 2D energy fields, in all possible planes, fill the entire space to provide an all-encompassing 'universal medium'. Matter is inert; all actions are performed by and through 2D energy fields. Attempt by unstable 2D energy fields to regain their homogeneity produce phenomenon of 'gravitation'. Gravitational attraction is relatively a minor (dynamic) aspect of gravitation. Gravitational actions create 3D matter from universal medium and maintain stability of 3D matter bodies, created.

Basic 3D matter particles ('photons' – matter-corpuscles of light-like radiations) are created by 2D energy fields under appropriate conditions from quanta of matter, detached from universal medium. 2D energy fields, under suitable conditions, combine photons to develop primary 3D matter particles, fundamental particles, atoms and other macro bodies, found in nature.

'Distortions' in 2D energy fields about a matter body sustain matter body's integrity and stability. Distorted region in universal medium about a matter body is its 'distortion field'. Distortion fields of constituent molecules of a macro body, together, form macro body's 'matter field'. Gravitational attractions, in conjunction with efforts due to interactions between distortion fields of molecules, keep molecules of a macro body at appropriate distance from each other, within the macro body. In any stable macro body, in all physical states, its constituent atoms/molecules keep definite and steady relative positions and distances from their neighbours. Continuous molecular/atomic random motions, envisaged in kinetic theory of gas, corresponding to temperature (and hence to energy level) of a macro body (introduced to justify internal pressure of a fluid macro body), is a myth. Internal pressure of a macro body is the result of proximities of distortion fields of neighbouring atoms/molecules in the macro body. Moving constituent atoms/molecules towards each other (or their expansion during heating) increases internal pressure of the macro body (or pressure on container wall) by their constriction in available space.

External pressure on constituent primary 3D matter particles affected by internal pressure of a macro body determines their matter-content and corresponding energy about them. Relative quantity of matter-content of primary particles in a macro body is understood as state of heat/coldness of a macro body. Increasing external pressure on a primary 3D matter particle reduces its matter-content and increases its volume. [Generally, increasing internal pressure of a macro body, reduces its matter-density and increases its volume].

Physical states are applicable only to macro bodies. Primarily, it is the inter-atomic/molecular distances that determine physical state of a macro body. Matter contents of atoms/molecules determine inter-atomic/molecular distances in a composite macro body.

Conclusions, expressed in this article, are according to 'Hypothesis of MATTER'. For details, kindly refer to the same [1].

Heating and cooling:

Heat or cold of a macro body is the relative status of quantity of matter contents in its 'primary 3D matter particles' with respect to quantity of matter contents in primary 3D matter particles of a reference body at standard (room) temperature. Quantity of matter content (and corresponding energy content about) of a primary 3D matter particle is determined by surrounding external pressure on it. As external pressure increases, a primary 3D matter particle loses part of its matter content into universal medium (along with corresponding energy content) and its volume expands. This process is heating. As external pressure reduces, a primary 3D matter particle gains matter content from universal medium (along with corresponding energy content) and shrinks in volume. This process is cooling. [These conclusions are contrary to current physical theories and beliefs]. 'Hypothesis on MATTER' describes a logical mechanism, operated by universal medium, for these actions. Raising external pressure lowers total matter content of a macro body (with corresponding reduction in its energy content) and increases its volume. This generally leads to reduction in matter-density of the macro body. Lowering external pressure raises total matter content of a macro body (with corresponding augmentation in its energy content) and reduces its volume. This generally leads to an increase in matter-density of the macro body. A macro body, existing in free space is at its highest matter (and energy) content and is at its lowest volume.

On cooling, matter and energy contents of all (primary 3D matter particles and hence) atoms in a macro body increase and their volumes decrease. Increase in matter content increases gravitational (apparent) attraction between atoms in a macro body. During cooling, atoms of a macro body move nearer and inter-atomic distances in the macro body reduce. Conversely; on heating, matter and energy contents of all atoms in a macro body decrease and their volumes increase. Reduction in matter content reduces gravitational (apparent) attraction between atoms in a macro body. During heating, atoms of a macro body move farther and inter-atomic distances in the macro body increase.

Mpemba effect:

If two equal volumes of water, one slightly warmer than the other, are placed in similar external conditions to freeze, the warmer water is noticed to freeze before the other. This phenomenon is called 'mpemba effect' (named after Erasto B. Mpemba, who noticed this phenomenon first, in modern times).

Let us consider two identical liquid macro bodies, 'A' and 'B', being cooled under similar surrounding conditions. Let freezing temperature of the body-material is t_0° c. In macro bodies' stable states, all their molecules will be in steady relative positions. There are no random motions corresponding to temperature level of the macro bodies, as is believed today. We may neglect effects of 'Brownian motion' or any other natural (identical) convection in the liquid macro bodies.

Let initial temperature of macro body, 'A', is t_1° c. In this stable state, all molecules of the macro body are steady in their relative positions. They have no linear acceleration or linear velocity towards neighbouring molecules. Cooling of macro body is affected by a reduction in its surrounding external pressure, produced by direct contact with cooler material. During cooling, constituent 3D primary matter particles of molecules gain matter content from surrounding universal medium. As cooling process of macro body starts, its molecules are moved towards each other at increasing linear acceleration due to gravitation. Their linear accelerations towards each other are subscribed by increases in gravitational attraction between them, due to increases in their matter contents and reduction in distance between them. As and when temperature of the macro body reaches freezing point t_0°c, neighbouring molecules in the macro body would have reached the proximity corresponding to freezing state of body-material. The macro body changes its physical state from liquid to solid.

Let the initial temperature of macro body, 'B', is t_2° c, slightly higher than initial temperature of macro body, 'A'. In this stable state, all molecules of the macro body are steady in their relative positions. They have no linear acceleration or linear velocity towards neighbouring molecules. Cooling of the macro body is affected by a reduction in its surrounding external pressure, produced by direct contact with cooler material. During cooling, constituent primary 3D matter particles of molecules gain matter content from surrounding universal medium. As cooling process of macro body starts, its molecules are moved towards each other at increasing acceleration due to gravitation. Their accelerations towards each other are subscribed by increases in gravitational attraction between them, due to increases in their matter contents and reduction in distance between them. As and when temperature of macro body 'B' reaches temperature t_1° c, its molecules have already gained certain resultant velocity towards their neighbours. Although matter contents and mutual gravitational attraction of molecules, at temperature t_1° c, are equal to those of atoms in macro body, 'A' (during its initial stage of cooling), these molecules are already under certain linear velocity towards their neighbours.

Further motions of these molecules are governed by accelerations due to gravitational attraction, as in the case of body 'A', over and above their current linear velocities. Because of their initial linear velocities at temperature t_1°c, average velocities of molecules in macro body 'B', during its transition from temperature t_1°c to t_0°c are greater than average velocity of molecules in macro body 'A', during similar transition. Hence, time taken by macro body 'B' (which is initially at slightly higher temperature, t_2° c) to change its temperature from t_1° c to t_0° c is less than the time required for macro body 'A' to change its temperature through the same range.

Figure 1 shows hypothetical cooling graphs of three identical samples of water, on either sides of its freezing point. Therefore, graphs are not according to scale. They are intended to illustrate the principle rather than to express definite experimental results. $A_1A_2A_3A_4$ shows cooling graph of a sample of hot water. $B_1B_2B_3B_4$ shows cooling graph of a sample of warm water. $C_1C_2C_3C_4$ shows cooling graph of a sample of slightly cooler water. Time is marked on horizontal coordinate. Temperature is measured on vertical coordinate. Relative distances between neighbouring molecules of water are assumed to be proportional to temperature of each sample.

A_1 is initial temperature of hot water. As cooling of this sample proceeds, its freezing point will be reached in time corresponding to position A_2. During latent stage from A_2 to A_3, temperature of the sample

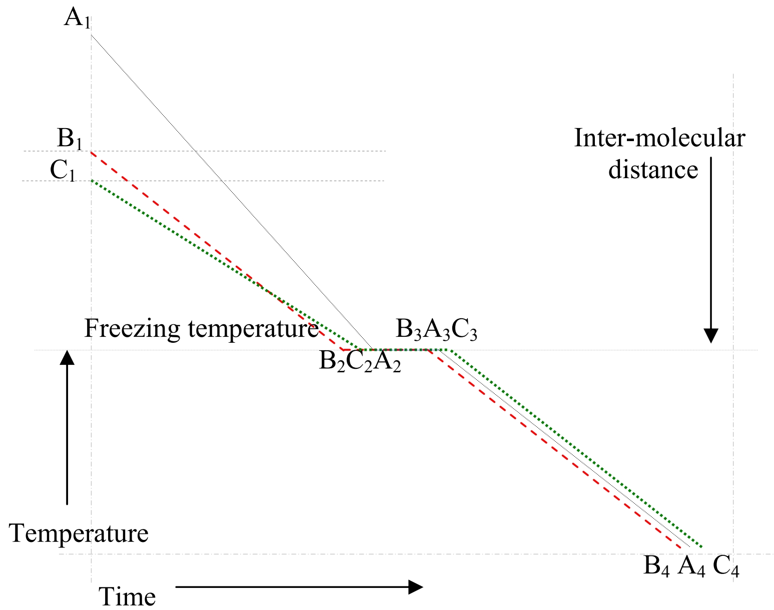

Figure 1

will remain steady, while whole of the sample is frozen. Thereafter, the sample will continue to cool till sample's temperature reaches minimum possible temperature (absolute zero).

B_1 is initial temperature of warmer water. As cooling of this sample proceeds, its freezing point will be reached in time corresponding to position B_2. During latent stage from B_2 to B_3, temperature of the sample will remain steady, while whole of the sample is frozen. Thereafter, the sample will continue to cool till sample's temperature reaches minimum possible temperature (absolute zero).

C_1 is initial temperature of cooler water. As cooling of this sample proceeds, its freezing point will be reached in time corresponding to position C_2. During latent stage from C_2 to C_3, temperature of the sample will remain steady, while whole of the sample is frozen. Thereafter, the sample will continue to cool till sample's temperature reaches minimum possible temperature (absolute zero).

Comparing graphs of warmer and slightly cooler samples, B_1 is more than C_1. When temperature of warmer sample reaches initial temperature of cooler sample, its molecules already have certain relative velocity towards their neighbours and rate of its cooling is greater as shown by greater slope of B_1B_2, compared to A_1A_2. Hence, warmer sample will reach freezing temperature at B_2 earlier than cooler sample reaches freezing temperature at A_2.

Duration of latent stage depends on the rate cooling. Duration of latent state of hot water at its freezing is much shorter than durations for other two samples. Duration of latent stage of cooler sample is longest. Cooling process beyond freezing point will commence as soon as latent stage is completed. If cooling is continued, warmer sample will reach absolute zero temperature, earlier than other two samples. Cooler sample will be the last to reach absolute zero temperature.

Rate of cooling (absorption of matter) by constituent primary 3D matter particles of a macro body depends on the difference between surrounding pressure (room temperature) and internal pressure (temperature) of the macro body. Whatever be the temperature of a macro body at any stage, its rate of cooling depends on initial conditions (difference between room temperature and temperature at the center of the macro body, when the macro body has started its cooling process). That is to say, that the rate of cooling of a macro body does not directly depend only on its current temperature difference with room temperature at any instant, but it depends also on the initial difference between temperature of the macro body and the room temperature, when the cooling process started. In the same conditions of room temperature, a slightly warmer macro body will cool down faster than a slightly cooler macro body. If initial temperature difference between the macro bodies is very little, total time required for a hotter macro body to cool through certain range of temperature may be less than the total time required for a cooler macro body to cool through the same range of temperature. Thus, under same external conditions, slightly warmer water freezes faster than identical quantity of cooler water. This phenomenon is called the 'mpemba effect'.

Up to a smaller extent, parameters of surroundings, rate of evaporation, convection currents, changes in volume of fluid, initial temperature, nature of containers etc. may have their own influences on the rate of cooling and time taken to freeze fluids. However, main reason for mpemba effect remains the product of linear accelerations of constituent molecules of macro bodies towards each other, due to any reason.

Similar actions take place during heating of macro bodies also, but in reverse order. Slightly cooler macro body may reach next latent stage before slightly warmer macro body, under identical surrounding conditions. Thus, it is possible that slightly cooler macro body to reach higher latent stage earlier than slightly warmer but identical macro body under similar surrounding conditions.

Conclusion:

Phenomenon of 'Mpemba effect' is caused by linear accelerations of constituent molecules of macro bodies towards each other, while they are cooled down.

Reference:

References [1] and [4] are self-published by the author. They are neither reviewed nor edited.

[1] Nainan K. Varghese, *Hypothesis on MATTER* (second edition), (2008).
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[4] Nainan. K. Varghese, ARTICLES, http://www.matterdoc.info

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