

MPEMBA EFFECT

According to 'MATTER (Re-examined)'

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Abstract: Two equal volumes of water, one slightly warmer than the other, when placed in similar external conditions to freeze, the warmer water is noticed to freeze before the other. This phenomenon (called the Mpemba effect) is the result of a difference in the rates of interatomic movements during the cooling stages of macrobodies with different initial temperatures.

Keywords: Heating, Cooling, Latent stage, Mpemba effect.

Introduction:

Different physical states are applicable only to macrobodies. Primarily, it is the inter-atomic/molecular distances that determine the physical state of a macrobody. 3D matter-content levels of atoms/molecules determine inter-atomic/molecular distances in a composite macrobody. Heating or compressing a macrobody reduces matter-content levels of its constituent 3D matter-particles. Similarly, cooling or reducing compression on a macrobody increases matter-content levels of its constituent 3D matter-particles.

Heat or cold of a macrobody is the relative status of the quantity of 3D matter its 'primary 3D matter particles' contain with respect to the quantity of 3D matter in the primary 3D matter particles of a reference macrobody at standard external conditions. The quantity of 3D matter (and corresponding energy content) of a primary 3D matter particle is determined by the surrounding external pressure on it. As the external pressure increases, a primary 3D matter particle loses part of its 3D matter content into the universal medium (along with a loss of corresponding energy content), and its volume expands. This process is the heating. As external pressure reduces, a primary 3D matter particle gains 3D matter-content from the universal medium (along with an increase in corresponding energy content) and shrinks its volume. This process is cooling. [These conclusions are contrary to current physical theories and beliefs]. An alternative concept, presented in the book 'MATTER (Re-examined)' [3] describes a logical mechanism, operated by a universal medium, for these actions.

Accordingly, raising the external pressure lowers the total 3D matter-content of a macrobody (with corresponding reduction in its energy content) and increases its volume. This generally leads to a reduction in the 3D matter-density of the macrobody. Lowering external pressure raises the total 3D matter-content of a macrobody (with a corresponding increase in its energy content) and reduces its volume. This generally leads to an increase in the 3D matter-density of the macrobody. A macrobody, existing in free space, is at its highest 3D matter (and energy) content and is at its lowest volume.

On cooling, the 3D matter and energy contents of all (primary 3D matter-particles and hence) atoms in a macrobody increase, and their volumes decrease. Increase in the 3D matter-content increases gravitational attraction between atoms in a macrobody. During cooling, atoms of a macrobody move nearer and inter-atomic distances reduce. Conversely, on heating, the 3D matter and energy contents of all atoms in a macrobody decrease, and their volumes increase. A reduction in the 3D matter-content reduces gravitational attraction between atoms in a macrobody. During heating, atoms of a macrobody move farther and inter-atomic distances in the macrobody 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 the 'mpemba effect' (named after Erasto B. Mpemba, who noticed this phenomenon first, in modern times).

Let us consider two identical liquid macrobodies, 'A' and 'B', being cooled under similar surrounding conditions. Let the freezing temperature of the body material is t_0 ° c. In macrobodies' stable states, all their

molecules are in steady relative positions. There are no random motions corresponding to the temperature level of the macrobodies, as is believed today. We may neglect the effects of 'Brownian motion' or any other natural (identical) convection in liquid macrobodies.

Let the initial temperature of macrobody, A, is $t_1^\circ \text{C}$. In this stable state, all molecules of the macrobody are steady in their relative positions. They have no linear acceleration or linear velocity towards neighbouring molecules. Cooling of macrobody 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 3D matter-content from the surrounding universal medium. As the cooling process of macrobody starts, its molecules move towards each other at an increasing linear acceleration due to gravitational attraction. Their linear accelerations towards each other are contributed by increases in gravitational attraction between them, due to increases in their 3D matter-contents and reduction in the distance between them. As and when the temperature of the macrobody reaches the freezing point $t_0^\circ \text{C}$, neighbouring molecules would have reached a certain proximity corresponding to the freezing state of the body material. The macrobody, A, changes its physical state from a liquid to a solid.

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

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

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

A_1 is the 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 the latent stage from A_2 to A_3 , the temperature of the sample remains steady, while the whole of the sample is frozen. Thereafter, the sample continues to cool till sample's temperature reaches the minimum possible temperature (absolute zero).

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

C_1 is the 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 the latent stage from C_2 to C_3 , the temperature of the sample remains steady, while the whole of the sample is frozen. Thereafter, the sample continues to cool till sample's temperature reaches the minimum possible temperature (absolute zero).

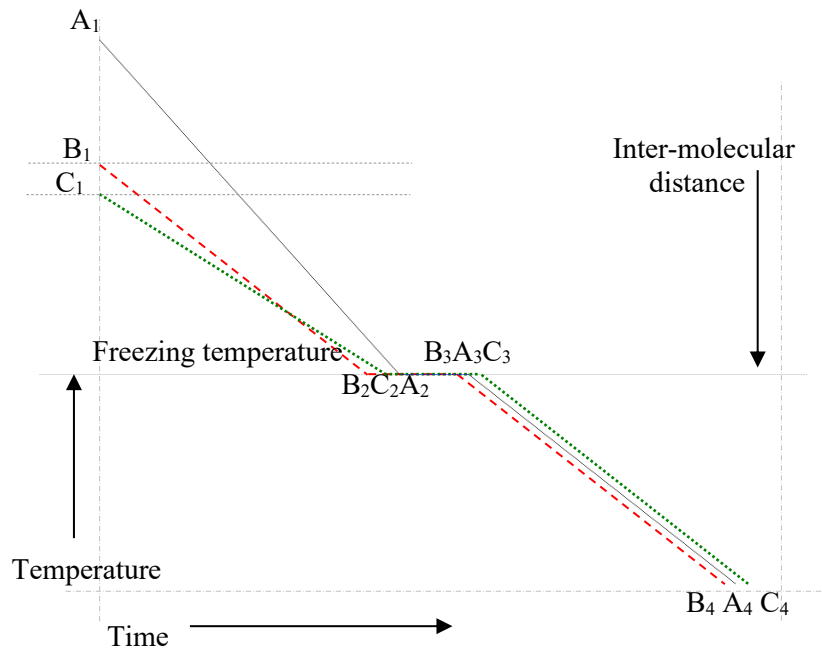


Figure 1

Comparing the graphs of warmer and cooler samples, temperature B_1 is higher than C_1 . When the temperature of the warmer sample reaches the initial temperature of the cooler sample, its molecules already have a certain relative velocity towards their neighbours, and the rate of its cooling is greater, as shown by the greater slope of B_1B_2 , compared to C_1C_2 . Hence, the warmer sample will reach the freezing temperature at B_2 earlier than the cooler sample, which reaches the freezing temperature at C_2 .

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

The rate of cooling (absorption of 3D matter-content) by constituent primary 3D matter-particles of a macrobody depends on the difference between the surrounding pressure (room temperature) and internal pressure (temperature) of the macrobody. Whatever the temperature of a macrobody at any stage, its rate of cooling depends on initial conditions (the difference between room temperature and the temperature at the center of the macrobody when it has started its cooling process). That is to say, the rate of cooling of a macrobody does not depend only on its current temperature difference with room temperature at any instant, but it also depends on the initial difference between the temperature of the macrobody and the room temperature when the cooling process started.

In the same conditions of room temperature, a slightly warmer macrobody will cool down faster than a slightly cooler macrobody. If the initial temperature difference between macrobodies is very little, the total time required for a hotter macrobody to cool through a certain range of temperature may be less than the total time required for a cooler macrobody to cool through the same range of temperature. Thus, under the same external conditions, slightly warmer water freezes faster than an identical quantity of cooler water. This phenomenon is called the 'Mpemba effect'.

To a certain extent, the parameters of the surrounding universal medium, the rate of evaporation, convection currents, changes in the volume of fluid, initial temperature, nature of containers, etc., have their own influences on the rate of cooling and time taken to freeze fluids. However, the main reason for Mpemba effect remains the product of linear accelerations of constituent molecules of macrobodies towards each other, for any reason. Convictional currents in macrobodies at any stage are bound to adversely affect the Mpemba effect.

Similar actions take place also during the heating of macrobodies, but in reverse order. A slightly cooler macrobody may reach the next latent stage before a slightly warmer macrobody, under identical surrounding

conditions. Thus, it is possible that a slightly cooler macrobody reaches a higher latent stage, earlier than a slightly warmer but identical macrobody under similar surrounding conditions.

Conclusion:

The phenomenon of the 'Mpemba effect' in fluid macrobodies is caused by linear accelerations of their constituent molecules towards each other while they are being cooled.

References:

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