Molecular motion in fluids (© March 2017; copy at Lerners LLP, London, Ontario)

Abstract
It is impossible that random collisions of water molecules with colloid particles one trillion times their mass cause Brownian movement. Molecular kinesis in fluids, and thus laminar flow, may be restricted to molecular dimensions. Simple harmonic (SH) molecular oscillation should allow random walk diffusion. The oscillation might be secondary to SH atomic oscillation. Flow-generated intense focal boundary layer transverse sound waves might freeze laminar slip, causing laminar interlocking. "Frozen" foci of laminar slip might create head-over-heels vortices, perhaps the long-sought origin and nature of transition to turbulence.

Key words: black body radiation, laminar freezing, molecular kinesis. oscillations and vibrations, photon emission spectrum, transition to turbulence

1. Introduction

Brown described constant zigzag movement segments in microscopic organelles (amyloplasts) extruded into an aqueous suspension from ruptured pollen grains of Clarksia pulchella. Initially considered a manifestation of organic vitality, further investigation showed finely divided inorganic substances exhibited similar motion (Brown 1827). The accepted explanation is that particle motion arises from collisions with randomly rapidly moving water molecules (Einstein 1905), but the extreme mass difference between a water molecule and a colloid particle renders this impossible. Whether Brownian motion is from intrinsic force generation or from extrinsic forces remains unresolved.

3. Discussion

Consider a Brownian particle 2.79 microns in diameter (0.00279 mm) compared to a water molecule (d = 0.000000279 mm). The particle is 0.00279 / 0.000000279, (10,000) times the diameter of a water molecule. Since mass varies directly with volume (a cubic function of the radius), the particle weighs about $10{,}000^3$ (one trillion) times the water molecule's mass. Axiomatically, by Newtonian momentum-exchange physics, collisions from random molecular motion of one, or one thousand, water molecules, at any velocity, cannot budge a Brownian particle – especially through water's mass and viscosity – in zigzag linear segments many times the particle's diameter (Hamilton 2015, 16-17), as is currently believed.

Although thermodynamics has been implicated as a factor in Brownian movement (Einstein 1905), heating creates a smoothly curved flowing motion (convection currents), and should not cause the knee-jerk sharply-angulated zigzag linear motion segments characteristic of Brownian motion (Hamilton 2011: p, 16).

The constant translational motion of water molecules in non-particulate (Newtonian) fluids need not be in the range of Brownian particle movement and may even be in the range of molecular dimensions. Any new theory must account for diffusion.

Molecular/atomic coherent oscillation

Consider that fluid molecular kinesis is based on SH oscillation of molecules around their centres of mass, the oscillation amplitude varying directly with the temperature. Adjacent oscillating molecules would bump each other out of original positions. This should still allow diffusion of molecules, using Einstein's random walk analogy. Eccentric and differing atomic weights of elements comprising each molecule within electron ring binding would introduce wobbling in molecular oscillations, contributing to random walk diffusion.

However, molecular oscillation might originate from atomic oscillation, with each element having a signature SH atomic oscillation frequency, with temperature-related changes in amplitude. As with a pendulum, the frequency might remain constant, regardless of amplitude. Each independently oscillating atom would cause a compound molecule to wobble by interaction between different atomic oscillation frequencies. The wobbling should contribute to diffusion.

Masses exhibit black body radiation [Kirchhoff 1860; Planck 1900], with the infrared spectrum revealing the temperature. Thus, electromagnetic radiation intensity is a measure of the total vibrational kinetic energy of heat – directly related to the Kelvin temperature.

Because atoms of each element have specific arrangements of orbital electrons, and of nuclear protons, SH oscillations of these electrically charged atomic components might create electro-magnetic radiation spectra specific for each element on the periodic table. Heating to incandescence creates such an element-specific photon emission spectrum [Alter 1854; Hamilton, 2015: p. 17]. A similar specific emission spectrum might exist as a component of black body radiation but, because the amplitudes would be so low at these temperatures, the spectra remain undetected to date. If one were to plot the intensity of the photon emission spectrum against the temperature as it is lowered from incandescence one might predict the expected intensity at room temperature.

According to current understanding of Brownian motion and, because the scale of molecular motion and Brownian particle movement occurs in all planes, the thickness of each lamina should be able to contain such motion. However, if fluid molecular kinesis is restricted to atomic-molecular oscillation, one should be able to consider laminar flow in laminae approaching molecular dimensions.

Sound energy, particularly of specific SH frequencies, directed transversely through boundary layer laminae [Brown 1932; Schubauer and Skramstad, 1943; Hamilton 1980: 45], precipitates turbulence at lower Reynolds numbers. Simple harmonic sound as a precipitating factor in the physics of transition from laminar to turbulent flow was suggested by Elizabeth Barrett Browning in her poem, Aurora Leigh (1856); she noted that the pealing of a particular church bell triggered wavering turbulence in the previously steady laminar-flow flames of street gaslights: "...gaslights tremble in the streets and squares" (Browning 1858; Hair 2016). Her instantly acclaimed poem might have alerted scientists (e.g., Leconte 1859) to the influence of SH sound as a precipitating cause of turbulence. A contemporary flurry of scientific interest in this effect culminated in Sir John Tyndall (1867) deducing that specific SH sounds (a whistle), directed perpendicular to the flow had waves that blended with similar SH waves created by friction along the boundaries of tubes, amplifying them and triggering the phenomenon of high-resistance turbulent flow.

An oscillation in a fluid is a vibration in a mass of that fluid, which creates a sound wave. SH long-crested oscillations (vibrations) arise from fluid shear in the boundary layer during transition, gradually increasing in amplitude as the flow rate continues to rise. Just before turbulent flow erupts, isolated boundary layer spikes of amplified in-phase Tollmien-Schlichting (T-S) oscillations (i.e., SH vibrations), emerge (Schubauer and Skramstad 1943: Hamilton 1980: p.50, Hamilton 2015: p. 65), which must signify focal areas of high amplitude ("spikes" in) transverse boundary layer sound waves. Ultra-microscopic laminae subjected to such intense transverse sound waves result in focal high energy oscillation of molecules (as sound waves), which pass transversely through the molecular layers flowing longitudinally as ultra-microscopically thin laminae.

These spikes of high energy transverse sound should interfere focally with laminar slip – potentially interlocking laminae longitudinally, causing sudden focal transference of resistance to the braking effect of boundary friction. This might rip "frozen" chunks out of fast-flowing long-crested wave fronts, creating the head-over-heels vortices of turbulent spots, with noise. Further increase in flow rate would produce many head-over-heels vortices as noisy generalized turbulence erupts with the high resistance of generalized boundary layer laminar interlocking of established turbulent flow (Hamilton 2015, p. 17).

Emmons described the emergence of similar foci of turbulence during transition in laminar water flow along a glass plate. These turbulent spots, which he termed "turbulent sources," are analogous to the Reynolds "flashes of turbulence" in cylinders (Reynolds 1883; Hamilton 2015: 16). The Emmons V-shaped "turbulent sources," depicting spots of laminar freezing, slide along the shiny smooth glass surface; they resemble the V-shaped wake of a focal boundary obstruction to flow (a stationary un-laminable stone in a streambed). Whereas a turbulent source of laminar freezing slides along the shiny glass surface, the un-laminable stone is fixed to the boundary, arresting the V-shaped wake, suggesting a standing wave nature to the shear waves (Hamilton 2011: 57)

In cylinders, sudden laminar interlocking would explain the abrupt change from the parabolic iso-velocity profile of laminar flow into the flattened iso-velocity profile of established turbulent flow (with laminar interlocking) accompanied by high flow resistance (Hamilton 1980: p. 62).

As the temperature approaches 0 degrees K., the amplitude of atomic/molecular oscillation approaches zero, with the thickness of these smooth (and now slick) laminae approaching molecular dimensions, explaining the super-fluidity of helium at such temperatures [Allen and Misener 1938; Kapitza, 1938].

4. Conclusions

1. Brownian movement remains unexplained.
2. Fluid molecular kinesis might be in the form of molecular oscillation that may be secondary to simple harmonic atomic oscillation, with atoms of each element having signature oscillation frequencies, associated with element-specific photon emission spectra.
3. Simple harmonic molecular oscillation should cause diffusion.
4. Laminar flow might be possible at ultramicroscopic dimensions where transverse boundary layer flow-generated amplified coherent transverse sound may trigger laminar interlocking, accompanied by boundary layer vortices – the elusive site and enigmatic cause of transition to turbulence.

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Additional information

This theory of transition to turbulence being due to SH boundary-layer-transverse sound generation causing laminar interlocking with boundary layer vortices and high flow resistance was proposed in a paper to the Journal of Fluid Mechanics in 1975, but was rejected (the reviewer's criticism follows this note). I no longer have a copy of this paper in my files, but it would be similar to my website posting of a paper I submitted to the Royal College of Physicians and Surgeons of Canada (1975). An original copy of the JFM article is probably in a file cabinet of Lerners LLP, London along with much that I have thought and written about Fluid Dynamics since the early 1970s. My friend and lawyer since university days, Earl Cherniak, has kept this information on file because he believed that it might be of some scientific and historical importance.

Also to follow is a copy of a note I received from Professor George Bachelor, the editor of JFM to whom I sent a copy of my first book, "Patterns in Fluid Flow Paradoxes – Variations on a Theme."

After releasing the book (1980) I left research and writing about transition to turbulence for twenty-five years until, in my retirement, I came across an image of highly organized transverse flows in turbulence in cylinders in a Physics Today editorial by Editor Fitzgerald. He created an image showing three identical transverse flow patterns in equal cylinder sectors – a centripetal streaming flow, flanked by two similar but counter0riating vortices. This pattern duplicated the transverse flows found in turbulence in tubes with equilateral triangular cross-sections found by Nikuradse in 1930 and which were very significant in my book. Nikuradse had hoped to find these flow patterns in cylinders but 1930 technology failed him. Fitzgerald's flow pattern spurred me on to resume research into the physics of transition to turbulence – which continues unabated to date. However, the essentials of the theory remain similar to those presented in 1980.

The accepted theory of the physics of Brownian motion suggests that each lamina in laminar flow should contain the ranges of Brownian particle motion because the particle motion is caused by collisions with randomly moving water molecules in aqueous suspensions. There has been a failure to factor in the mass disparity between a water molecule and a colloid particle – one trillion to one. It is impossible for one, or even one thousand water molecules to budge a Brownian particle. The motion of fluid molecules might be much more restricted, even confined to being SH oscillation of molecules around their centres of mass, as suggested in “Simple Harmonics” (2015), while still allowing diffusion to occur using Einstein’s “random walk” analogy. SH molecular oscillation would allow boundary layer laminar flow at molecular dimensions where transition to turbulence may originate along the boundary.

Here is the 1975 JFM reviewer’s criticism, followed by Prof. George Bachelor’s 1990 note:

Report on "Patterns of Fluid Flow" by Gavin Hamilton

This paper is not suitable for publication owing to a number of misconceptions about the nature of fluid flow. The main thesis seems to be that the flat velocity profile in turbulent pipe flow results from a locking together of fluid laminae by ultrasonic wave motions. One logical inconsistency is that if ultrasonic waves are responsible for the rapid lateral mixing of soluble dye in his experiment 2 and in Reynolds experiment, then the fluid elements cannot at the same time be "locked" together. The author has not suggested a mechanism whereby lateral movement can be greatly enhanced while longitudinal slip is prevented. He has not understood how the measured flat velocity profile in turbulent flow is a mean profile, in which the vigorous random fluctuations, which are always measured, have been averaged out. He has also misunderstood the nature of laminar flow. The concept of infinitely thin fluid laminae is a mathematical abstraction, consistent with the continuum model of a fluid as long as the length-scale of the observed motions is much greater than molecular mean free paths. In fact, on the molecular scale, vigorous random motion is going on even in Poiseuille flow; it is the interaction of laterally moving molecules which causes there to be viscosity, modelled in the continuum theory by internal friction between hypothetical laminae.

The observations of an apparently smooth but distorted surface of a jet emerging from an arifice maybe explained either by the effect of surface tension, which prevents disturbances of very small wavelength occurring on the surface, or by the fact that the Reynolds number (not given) is too small for completely random turbulence to be present, or both.

The observations of arteriographic standing waves are interesting; I was not previously aware of them. It is difficult to speculate about their origin in the absence of further information. For example, if they are standing waves, then the artery walls should be pulsating in and out at the wave frequency. Are they pulsating? If so at what frequency? I would be surprised if it were in the mega Hertz range, because the amplitude of fluid motions generated by resonating sound waves is not normally as great as that shown in fig. 1. Furthermore, the compliance of the artery wall is much greater than that of the blood itself, and the restoring force in a wave of this amplitude would be provided by wall elasticity and not compressibility of blood. (See McDonald, Blood Flow in Arteries.) In that case, with wave speed about $8ms^{-1}$, the frequency would be about 2000Hz (still very high).

On the other hand, maybe the artery wall is not pulsating at high frequency, in which case the waves must arise by some other mechanism, as yet unknown. We could infer more about their origin if we were given full details of the pressure, diameter, flow-rate, amplitude, frequency, etc., in the affected artery.