Fundamental Errors Regarding the Physics of Heat

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In physics today, heat is thermal energy in transfer because of a difference in temperature. This flux of thermal energy is typically quantified in units of watts per square meter. One watt equals one joule of energy flowing each second. Physicists assume that heat from different sources can be added together and that the greater the net amount of heat flowing into a body of solid matter, the hotter that body will become.

Physics textbooks emphasize that heat is not a substance, it is just a numeric amount. But a numeric amount of what? Physics is about what is happening physically. What is thermal energy physically? What is the physical basis for what we perceive as temperature? What physically changes within matter, air, and space as heat flows spontaneously from higher temperature to lower temperature? What determines the rate at which heat flows?

In 1620, Francis Bacon wrote "the very essence of heat, or the substantial self of heat, is motion of small particles within matter and nothing else." Beginning in 1676, Gottfried Leibniz proposed that this motion was a "living force", ultimately leading to the concept that thermal energy is simply the kinetic energy of motion of all particles within solid matter.

Today we observe that all bonds holding atoms and molecules together are not rigid. They oscillate back and forth between forces of attraction caused by positive and negative charges and forces of repulsion caused by like charges. For molecular bonds, the frequencies of oscillation with the greatest amplitudes of oscillation are typically measured in trillions of cycles per second known as terahertz—frequencies much too high for us to perceive as oscillations.

In 1886, Heinrich Hertz discovered that oscillation of charge on the surface of matter generates a radio signal in air and space that consists of the same frequency and amplitude of oscillation as occurring on the surface of the antenna. This suggests that thermal radiation emitted by any body of solid matter because of its temperature is generated by all the molecular-bond-scale oscillators on the surface of a piece of solid matter, emitting a very broad spectrum of frequencies of oscillation that became known as the electromagnetic spectrum after Michael Faraday noted in 1845 that light responded to a magnetic field.

In 1900, Max Planck was able to devise an equation by trial and error that accurately calculates the amplitude of oscillation of thermal radiation observed in the laboratory for each frequency of oscillation as a function of the absolute temperature of the radiating piece of solid matter (Figure 1). This equation, which became known as Planck's empirical law, defines the physical basis for what we perceive as temperature. For a body to "possess" a temperature of 3300 Kelvin, for example, the amplitude of oscillation at each frequency of oscillation throughout the body must be at the level shown by the black line.

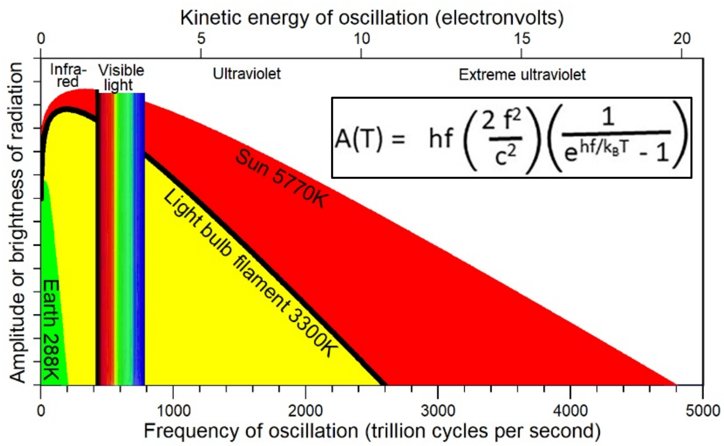

Figure 1. Planck's empirical law calculating the amplitude of oscillation or brightness at each frequency of oscillation as a function of the temperature of the radiating body. A is amplitude of oscillation, T is absolute temperature, h is the Planck constant, f is frequency of oscillation, c is the velocity of light, and k_B is the Boltzmann constant. A replacement for c^2 will need to be calibrated in the laboratory.

Note in Figure 1 that the higher the temperature of a body of solid matter, the greater the amplitude of oscillation at each and every frequency of oscillation and the higher the frequencies of oscillation that have the greatest amplitudes of oscillation. Thus, what must flow simultaneously as heat is amplitude of oscillation at each and every frequency of oscillation.

In 1900, most physicists were convinced that radiation travels as waves based on Maxwell's equations for electromagnetic waves formulated in the 1860s. Therefore, they plotted wavelength on the x-axis or wave frequency or wave number. They did not think in terms of frequency of oscillation. But waves involve the deformation of matter and Michelson and Morley showed in 1887 that there is no matter in space, no luminiferous aether, through which radiation can travel as waves. To this day, however, physicists have rationalized that there must be something special about electromagnetic waves that allows them to propagate as waves through space that is void of matter.

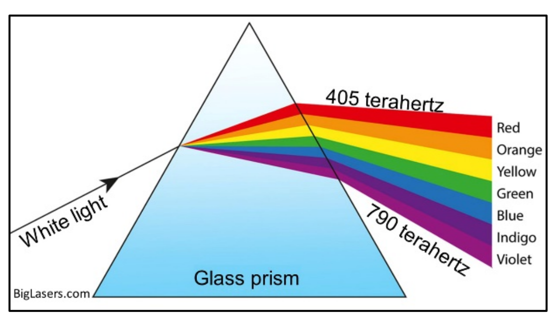

Figure 2. The color components of white light are separated spatially when passed through a prism.

In 1900, physicists used prisms to spatially separate the different frequencies, colors, contained within white light (Figure 2). They then placed an appropriate sensor within the space occupied by each color. They thought they were measuring the energy at each frequency, so they plotted energy on the y-axis as a function of wavelength on the x-axis.

As Planck developed his equation, he found it useful to think of the energy (E) of one tiny oscillator, which he called a resonator, as equal to the Planck constant (h) times the frequency of oscillation (f). This is why he made h and f the first two terms of his equation, causing the y-axis to have units of energy as expected. He did not stop to realize that if E=hf and frequency is plotted on the x-axis, then energy must also be plotted on an alternative x-axis as shown at the top of Figure 1. What physicists were measuring was not the kinetic energy of oscillation, it was what we perceive as the intensity or brightness of each frequency, which is determined by the amplitude of oscillation on the surface of solid matter, typically measured in picometers (10^{-12} meters).

A frictionless molecular-bond-scale oscillator has two primary physical properties: 1) frequency of oscillation and 2) amplitude of oscillation. Planck's empirical law calculates amplitude of oscillation as a function of frequency of oscillation for a specific temperature. I only show orders of magnitude for amplitude on the y-axis in Figure 1 because I think amplitude should be calibrated in the laboratory. The amplitudes of oscillation could vary in detail with chemical composition.

This simple equation, E=hf, now known as the Planck-Einstein relation, is thought today to be the definition of a photon, a quantum of energy—the physical basis for quantum mechanics. When thinking of one frequency of oscillation, E=hf is the energy required to cause chemical change to one bond such as the photoelectric effect or photo-dissociation. But frequency in nature is a broad spectrum of frequencies making up the well-known electromagnetic spectrum. A spectrum times a constant must equal a spectrum. Therefore, radiant thermal energy is a broad distribution or spectrum of kinetic energies of oscillation occurring simultaneously that is not quantized and that cannot be summarized as a single amount of watts per square meter as currently assumed in physics.

Currently, physicists integrate Planck's law as a function of frequency to calculate total energy. Integration is addition. It makes no physical sense to add frequencies of light together. Red light plus blue light does not equal ultraviolet light. It just equals some red light coexisting with some blue light.

Similarly, it makes no physical sense to add radiant kinetic energies of oscillation together because the energy at each frequency applies only to one specific molecular-bond-scale oscillator. Of course, there can be many oscillators oscillating at the same frequency, but that does not mean that there is a greater amount of energy because energy is a function of frequency, not amount. Thermal energy of oscillation of each sub-microscopic oscillator is a level of energy measured on a scale plotted on the upper x-axis in Figure 1. Similarly, there is no such physical thing as an amount of temperature. Temperature is measured as a level on some scale typically defined in units of Celsius, Fahrenheit, or Kelvin.

Physicists describe any observable, measurable property of a body of solid matter as either an extensive or an intensive physical property. Extensive physical properties are a function of the size or amount of an observable body of matter such as length, area, volume, weight, or quantity. Intensive physical properties, on the other hand, are a result of the molecular structure or oscillation of this molecular structure distributed throughout the body. These include thermal energy, heat, temperature, density, color, hardness, and pressure.

Extensive physical properties can be added together because they are related in one way or another to a physical amount of mass. Intensive physical properties, on the other hand, cannot be added together because they are the result of distributions of atoms and molecules at the sub-microscopic level. We can think of a distribution of some physical property as having an average value, but it is rarely practical to calculate such an average because we cannot measure the value for each member of the distribution.

For example, it is physically meaningless to add temperatures together. If you take two bodies of matter that are identical in every way except for temperature and connect them so that heat can flow by conduction or by radiation, the resulting temperature, when heat is no longer flowing, will be equal to the average of the two initial temperatures. If you subdivide a body into numerous pieces, the initial temperatures of all pieces will be identical, no matter their size. Temperature is a physical property internal to matter that is not affected by the size or amount of the body. In nature, temperatures are averaged together. It makes no physical sense to add temperatures together.

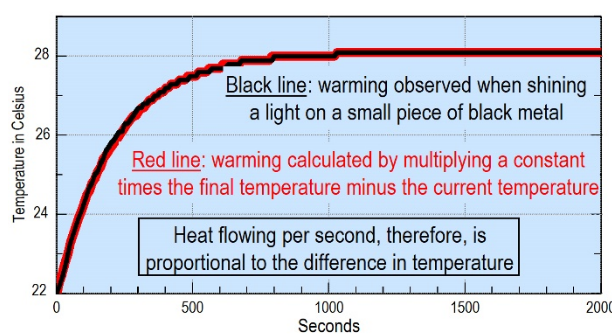

Figure 3. Heat flowing per second is proportional to the difference in temperature at that moment.

But temperatures can be subtracted from each other because it is the difference in temperature that is observed to determine the rate of flow, the flux, of temperature and of heat. All curves of warming or cooling of solid matter are observed to be asymptotic to the final temperature as shown in Figure 3 for warming. The black curve plots the temperature measured per unit time when shining a light on a small piece of thin black metal. The red line shows the temperature calculated by multiplying a constant times the final temperature minus the current temperature. The greater the difference in temperature, the greater the flow or flux of heat, and the faster the temperature increases. The greatest temperature difference is in the beginning. As the temperature difference approaches zero over time, flux approaches zero asymptotically. It takes longer and longer to completely warm the body.

But what physical process in nature calculates averages? The direct answer is resonance, a fundamental physical property of oscillating systems. Resonance is observed to occur when two oscillators are either physically touching in some way or are within line of sight. Through resonance, the oscillators share their amplitudes of oscillation so that both oscillators could end up with the average of their initial amplitudes of oscillation if we wait long enough. Resonance is all around us. We see by resonance. We hear by resonance. Resonance is what Albert Einstein called "spooky action at a distance," where something over there physically affects something over here even though we cannot observe any physical interconnection.

In summary, electromagnetic radiation is physically an extremely broad distribution, spectrum, or continuum of frequencies of oscillation of all the bonds holding solid matter together. The corresponding amplitudes of oscillation are determined by the temperature of the radiating body according to Planck's empirical law. What flows as heat spontaneously from higher temperature to lower temperature within matter and through air and space between matter is amplitude of oscillation at each and every frequency of oscillation, simultaneously. Electromagnetic radiation does not physically propagate as waves, particles, or wave-particle duality as currently assumed.

Everything that physically exists possesses a temperature. Therefore, the single most important physical process going on continuously throughout the universe, the pulse of matter, is cyclic oscillation of all the bonds holding matter together. Yet in classical physics we downplay the role of oscillation by deleting the units of cycles in dimensional analysis because we have not known what to do with them. The Planck constant is the number of joules of energy contained in one cycle per second; it is not the number of joule seconds as commonly tabulated. By throwing away the word cycles, we are throwing the baby out with the bathwater. Frequency of oscillation is nothing more or less than cycles per second.

Correcting these fundamental errors in the physics of heat makes many physical processes such as entanglement that quantum mechanics seeks to explain both physically intuitive and deterministic. It also shows unequivocally why greenhouse-warming theory is mistaken. Greenhouse-warming theory is built on three critical assumptions: 1) that heat is a flux, 2) that these fluxes, quantified as radiative forcings, are additive, and 3) that Earth gets hotter when the Earth-atmosphere system loses a lesser amount of heat to space than it absorbs from Sun. But heat is not a flux, heat is not additive, and there is no such physical thing as an amount of heat.

There are only three ways observed every day that air can be warmed: 1) by conduction as air touches Earth's sun-warmed surface and convects upward, 2) by dissociation in the stratosphere where solar ultraviolet radiation dissociates primarily oxygen and ozone, and 3) by ionization in the ionosphere where high-energy solar radiation ionizes available gases. Dissociation and ionization convert bond energy efficiently and completely into kinetic energy of linear motion, which is directly proportional to air temperature. Infrared radiation emitted by Earth does not have enough energy to dissociate anything. There is no known physical way that increases in emissions of greenhouse gases absorbing low-energy infrared radiation can warm Earth's surface.

As explained elsewhere, global warming observed throughout Earth history is explained in detail by depletion of the ozone layer. Less ozone absorbs less ultraviolet-B solar radiation, cooling the ozone layer and warming Earth, especially in polar regions where ozone depletion is greatest. Ultraviolet-B radiation that reaches Earth's surface is also observed to dissociate ground-level ozone pollution, warming air especially in populated areas as observed, and to penetrate oceans by tens of meters, raising ocean heat content as observed.

More detailed information is available as follows:

Article: Fundamental errors regarding the physics of heat

Article: We have already solved the global warming crisis

Article: The crisis in climate science

Book: What Really Causes Global Warming? Greenhouse Gases of Ozone Depletion?

Paper: The photochemistry of gas molecules in Earth's atmosphere determines the structure of the atmosphere and the average temperature at Earth's surface

Paper: Ozone depletion explains global warming

Paper: On the Planck-Einstein relation

Paper: Heat does not physically flow in the ways assumed by greenhouse-warming theory

Video: Listen up about climate change if you can bear it. I have some good news (1 minute)

Video: A most unexpected revolution in the physics of heat (13 minutes)

Video: TEDx talk: Volcanoes : A forge for climate change (18 minutes)

Video: The most expensive mistake ever made in the history of science (16 videos each 5 to 12 minutes)

Videos of talks at scientific meetings

Website: WhyClimateChanges.com

Website: OzoneDepletionTheory.info

Website: JustProveCO2.com

Website: Physically-Impossible.com